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(54) DEGRADED TPO AGONIST ANTIBODY

(57) The invention relates to a modified antibody which contains two or more H chain V regions and two or more L chain V regions of monoclonal antibody and can transduce a signal into cells by crosslinking TPO receptor to thereby exert TPO agonist action. The modified antibody can be used as a TPO signal transduction

agonist and, therefore, useful as a preventive and/or remedy for various diseases such as platelet-reduction-related blood diseases, thrombopenia following chemotherapy for cancer or leukemia, etc.

Description**TECHNICAL FIELD**

5 [0001] This invention relates to modified antibodies containing two or more H chain V regions and two or more L chain V regions of an antibody which show TPO agonist activity by crosslinking TPO receptor. The modified antibodies have TPO agonist activity of transducing a signal into cells by crosslinking TPO receptor and are useful as a medicine for various purposes.

10 BACKGROUND ART

[0002] Thrombopoietin (TPO) is a platelet production regulation factor found in 1994 and is known to be composed of a glycoprotein having a molecular weight of 70-80 thousands produced mainly in liver. Thrombopoietin is a cytokine which in bone marrow promotes platelet precursor cells to survive, proliferate, differentiate and mature, namely promotes megakaryocytes to differentiate and proliferate. Thrombopoietin (TPO) receptor was identified earlier than TPO as c-Mpl, a receptor of a specific factor to regulate platelet production (M. Souyri et al., Cell 63: 1137 (1990)). It was reported that c-Mpl is distributed mainly in platelet precursor cells, megakaryocytes and platelet cells and that the suppression of c-Mpl expression inhibits selectively megakaryocyte formation (M. Methia et al., Blood 82: 1395 (1993)). It was reported that the ligand to c-Mpl is TPO based on the results of proliferation assay of cells specific to c-Mpl ligand and purification of the ligand using c-Mpl (F. de Sauvage et al., Nature 369: 533 (1994); TD. Bartley et al., Cell 77: 1117 (1994)). At present Mpl is called TPO receptor. Therefore TPO and TPO receptor agonists have been expected to work as a therapeutic agent for thrombocytopenia, for example, as a medicine alleviating thrombocytopenia caused by bone marrow inhibition or bone marrow resection therapy for cancer patients.

[0003] On the other hand modified antibodies, especially antibodies with lowered molecular size, for example, single chain Fvs were developed to improve permeability into tissues and tumors by lowering molecular size and to produce by a recombinant method. Recently the dimers of single chain Fvs, especially bispecific-dimers have been used for crosslinking cells. Typical examples of such dimers are hetero-dimers of single chain Fvs recognizing antigens of cancer cells and antigens of host cells like NK cells and neutrophils (Kipriyanov et al., Int. J. Cancer, 77, 9763-9772, 1998). They were produced by construction technique of single chain Fv as modified antibodies, which are more effective in treating cancers by inducing intercellular crosslinking. It has been thought that the intercellular crosslinking is induced by antibodies and their fragments (e.g. Fab fragment), bispecific modified antibodies and even dimers of single chain Fvs, which are monospecific.

[0004] As antibodies capable of transducing a signal by crosslinking a cell surface molecule(s), there are known an antibody against EPO receptor involved in cell differentiation and proliferation (JP-A 2000-95800), an antibody against MuSK receptor (Xie et al., Nature Biotech. 15, 768-771, 1997) and others. There are also known an agonist antibody to TPO receptor, its fragments and single chain Fvs (W099/17364). However there have been no reports on single chain Fv dimers and modified antibodies such as single chain bivalent antibodies having agonist activity.

[0005] Noticing that single chain Fv monomers derived from monoclonal antibodies (antibody MABL-1 and antibody MABL-2 produced by the inventors) which induce apoptosis of IAP-containing cells do not induce apoptosis of cells and that dimers induce apoptosis, the inventors discovered that dimers crosslink (dimerize) IAP receptor on cell surface, thereby a signal is transduced into the cells and, as a result, apoptosis is induced. This suggests that monospecific single chain Fv dimers crosslink a cell surface molecule(s) (e.g. receptor) and transduce a signal like a ligand, thereby serving as an agonist.

[0006] Focusing on the intercellular crosslinking, it was discovered that the above-mentioned single chain Fv dimers do not cause hemagglutination while the above-mentioned monoclonal antibodies do. The same result was also observed with single chain bivalent antibodies (single chain polypeptides containing two H chain V regions and two L chain V regions). This suggests that monoclonal antibodies may form intercellular crosslinking while modified antibodies like single chain Fv dimers and single chain bivalent antibodies crosslink a cell surface molecule(s) but do not form intercellular crosslinking.

[0007] Based on those observations the inventors have newly discovered that modified antibodies such as single chain Fv dimers and single chain bivalent antibodies crosslink a cell surface molecule(s) or intracellular molecule(s) of the same cell, in addition to known intercellular crosslinking, and are suitable as a ligand to the molecule(s) (especially as a ligand which mimics the action of natural ligand).

[0008] Discovering further that an antibody molecule (whole IgG) can be modified into single chain Fv dimers, single chain bivalent antibodies and the like which crosslink a cell surface molecule(s), thereby reducing side effects caused by intercellular crosslinking and providing new medicines inducing only desired effect on the cell, the inventors completed the invention. The modified antibodies of the invention have remarkably high activity compared with whole antibodies (IgG) having the same V region as the modified antibodies. They have an improved permeability into tissues

due to the lowered molecular size compared with antibody molecules and the lack of constant regions.

DISCLOSURE OF INVENTION

- 5 [0009] An object of this invention is to provide low molecular-sized agonistic modified antibodies which contain two or more H chain V regions and two or more L chain V regions of a monoclonal antibody and have TPO agonist action by crosslinking TPO receptor.
- 10 [0010] Therefore, this invention relates the modified antibodies which contain two or more H chain V regions and two or more L chain V regions, preferably 2 to 6 each, especially preferably 2 to 4 each, most preferably two each, and show TPO agonist activity by crosslinking TPO receptor.
- 15 [0011] The "modified antibodies" in the specification mean any substances which contain two or more H chain V regions and two or more L chain V regions, wherein said V regions are combined directly or via linker through covalent bond or non-covalent bond. For example, polypeptides and compounds produced by combining each V region of antibody through a peptide linker or a chemical crosslinking agent and the like. Two or more H chain V regions and two or more L chain V regions used in the invention can be derived from the same antibody or from different antibodies.
- 20 [0012] Modified antibodies of the invention can be any things as long as they specifically recognize and crosslink TPO receptor and thereby can transduce a signal into cells. They include modified antibodies produced by further modifying a part of the amino acid sequence of V region of the modified antibodies.
- 25 [0013] Preferable examples of the modified antibodies of the invention are multimers such as dimers, trimers or tetramers of single chain Fv containing an H chain V region and an L chain V region, or single chain polypeptides containing two or more H chain V regions and two or more L chain V regions. When the modified antibodies of the invention are multimers of single chain Fv such as dimers, trimers, tetramers and the like containing an H chain V region and an L chain V region, it is preferable that the H chain V region and L chain V region existing in the same chain are not associated to form an antigen-binding site.
- 30 [0014] More preferable examples are dimers of the single chain Fv which contains an H chain V region and an L chain V region, or a single chain polypeptide containing two H chain V regions and two L chain V regions. The H chain V region and L chain V region are connected preferably through a linker in the modified antibodies.
- 35 [0015] The above-mentioned single chain Fv multimer includes a multimer by non-covalent bond, a multimer by a covalent bond through a crosslinking radical and a multimer through a crosslinking reagent (an antibody, an antibody fragment, or bivalent modified antibody). Conventional crosslinking radicals used for crosslinking peptides can be used as the crosslinking radicals to form the multimers. Examples are disulfide crosslinking by cysteine residue, other crosslinking radicals such as C₄ - C₁₀ alkylene (e.g. tetramethylene, pentamethylene, hexamethylene, heptamethylene and octamethylene, etc.) or C₄ - C₁₀ alkenylene (cis/trans -3-butylene, cis/trans-2-pentylene, cis/trans-3-pentenylene, cis/trans-3-hexenylene, etc.).
- 40 [0016] Moreover, the crosslinking reagent which can combine with a single chain Fv is, for example, an amino acid sequence which can optionally be introduced into Fv, for example, an antibody against FLAG sequence and the like or a fragment thereof, or a modified antibody originated from the antibody, for example, single chain Fv.
- 45 [0017] "TPO agonist action" in the specification means a biological action occurring in the cell(s) into which a signal is transduced by crosslinking TPO receptor, for example, proliferation, differentiation or growth stimulation of megakaryocytes, or platelet production.
- 50 [0018] ED50 of the TPO agonist action in the invention is determined by known methods for measuring agonist action. Examples for measurement are cell proliferation assay using TPO sensitive cell lines such as BaF/ml or UT7/TPO, measurement of phosphorylation of MPL protein, megakaryocyte colony assay by differentiation from bone marrow cells, in vivo mouse platelet recovery synthesis assay, measurement of expression induction of platelet antigen GPIIbIIIa (anti GPIIbIIIa) using human leukemia megakaryoblastic cell line (CMK) or measurement of polyploidy induction of megakaryoblastic cell line (DAMI). ED50 is a dose needed for achieving 50% reaction of the maximum activity set as 100% in the dose-reaction curve.
- 55 [0019] Preferable modified antibodies of the invention have TPO agonist action (ED50) equivalent to or better than that of an antibody having the same antigen-binding region as the modified antibody, namely the whole antibody (hereinafter "parent antibody") like IgG having the same pair of H chain V region and L chain V region as the pair of H chain V region and L chain V region forming antigen-biding region of the modified antibody. More preferable are those having TPO agonist action (ED50) more than two times higher than that of parent antibody, further preferably more than 5 times, most preferably more than 10 times. The invention includes modified antibodies with TPO agonist action containing H chain V region and L chain V region forming the same antigen-binding region as the parent antibody which binds to TPO receptor but has no TPO agonist action to the molecule.
- [0020] The compounds containing two or more H chain V regions and two or more L chain V regions of the invention can be any compounds which contain two or more H chain V regions and two or more L chain V regions of antibody and show TPO agonist action (ED50) equivalent to or better than that of thrombopoietin (TPO). Preferable are those

having TPO agonist action (ED50) more than two times higher than that of TPO, more preferably more than 5 times, most preferably more than 10 times.

[0021] The "compounds" mentioned here include not only modified antibodies of the invention but also any compounds containing two or more, preferably from 2 to 6, more preferably from 2 to 4, most preferably 2 antigen-binding regions such as whole antibodies or F(ab')₂.

[0022] Preferable modified antibodies or compounds of the invention containing two or more H chain V regions and two or more L chain V regions of antibody have an intercellular adhesion action (ED50) not more than 1/10 compared with the parent antibody, more preferably have no substantial intercellular adhesion action.

[0023] ED50 of the intercellular adhesion action mentioned in the above is determined by known methods for measuring intercellular adhesion action, for example, by the measurement of agglomeration of cells expressing TPO receptor.

[0024] The invention relates to DNAs which code for the modified antibodies.

[0025] The invention relates to animal cells or microorganisms which produce the modified antibodies.

[0026] The invention relates to use of the modified antibody as TPO agonist.

[0027] The invention relates to a method of transducing a signal into cells by crosslinking TPO receptor using the modified antibody and thereby inducing TPO agonist action such as proliferation, differentiation-induction or growth stimulation of megakaryocytes, platelet production, phosphorylation of TPO receptor protein and the like.

[0028] The invention relates to a medicine for treating thrombocytopenia etc. containing the modified antibody as active component.

[0029] The invention relates to use of the modified antibody as a medicine.

[0030] The invention relates to a method of screening or measuring the modified antibody, which contains two or more H chain V regions and two or more L chain V regions of antibody and shows TPO agonist action by crosslinking TPO receptor, that comprises 1) to prepare a modified antibody containing two or more H chain V regions and two or more L chain V regions of antibody and binding specifically to TPO receptor, 2) to contact the modified antibody with cells expressing TPO receptor and 3) to measure TPO agonist action which occurs in the cells by crosslinking TPO receptor. The method of measurement is useful for the quality control in producing the modified antibodies of the invention as a medicine and other purposes.

[0031] The modified antibodies can be mono-specific modified antibodies or multi-specific modified antibodies like bi-specific modified antibodies. Preferable are mono-specific modified antibodies.

[0032] The present invention also relates to modified antibodies whose H chain V region and/or L chain V region is H chain V region derived from human antibody and/or L chain V region derived from human antibody. The H chain V region and/or L chain V region derived from human antibody can be obtained by screening human monoclonal antibody library as described in WO99/10494. The H chain V region and L chain V region derived from human monoclonal antibodies produced by transgenic mouse and the like are also included.

[0033] The present invention further relates to modified antibodies whose H chain V regions and/or L chain V regions are humanized H chain V regions and/or humanized L chain V regions. Specifically, the humanized modified antibodies consist of the humanized L chain V region which comprises framework regions (FR) derived from an L chain V region of human monoclonal antibody and complementarity determining regions (hereinafter "CDR") derived from an L chain V region of non-human mammalian (e.g. mouse, rat, bovine, sheep, ape) monoclonal antibody and/or the humanized H chain V region which comprises FR derived from an H chain V region of human monoclonal antibody and CDR derived from an H chain V region of non-human mammalian (e.g. mouse, rat, bovine, sheep, ape) monoclonal antibody. In this case, the amino acid sequences of CDR and FR may be partially altered, e.g. deleted, replaced or added.

[0034] H chain V regions and/or L chain V regions of the modified antibodies of the invention can be H chain V regions and/or L chain V regions derived from monoclonal antibodies of animals other than human (such as mouse, rat, bovine, sheep, ape, chicken and the like). In this case, the amino acid sequences of CDR and FR may be partially altered, e.g. deleted, replaced or added.

[0035] The invention also relates to DNAs encoding the various modified antibodies as mentioned above and genetic engineering techniques for producing recombinant vectors comprising the DNAs.

[0036] The invention also relates to host cells transformed with the recombinant vectors. Examples of host cells are animal cells such as human cells, mouse cells or the like and microorganisms such as E. coli, Bacillus subtilis, yeast or the like.

[0037] The invention relates to a process for producing the modified antibodies, which comprises culturing the above-mentioned hosts and extracting the modified antibodies from the culture thereof.

[0038] The present invention further relates to a process for producing a dimer of the single chain Fv which comprises culturing host animal cells producing the single chain Fv in a serum-free medium to secrete the single chain Fv into the medium and isolating the dimer of the single chain Fv formed in the medium.

[0039] The present invention also relates to the use of the modified antibodies as TPO agonist. That is, it relates to a signal-transduction agonist which comprises as an active ingredient the modified antibody obtained as mentioned in

the above.

[0040] Therefore, the pharmaceutical preparations containing TPO agonist modified antibodies of the invention as an active ingredient are useful as preventives and/or remedies for platelet-reduction-related blood diseases, thrombocytopenia caused by chemotherapy of cancers or leukemia, and the like.

[0041] The modified antibodies of the present invention comprise two or more H chain V regions and two or more L chain V regions derived from antibodies. The structure of the modified antibodies may be a dimer of single chain Fv comprising one H chain V region and one L chain V region or a polypeptide comprising two H chain V regions and two L chain V regions. In the modified antibodies of the invention, the V regions of H chain and L chain are preferably linked through a peptide linker which consists of one or more amino acids. The resulting modified antibodies contain variable regions of antibodies and bind to the antigen with the same specificity as that of the original monoclonal antibodies.

H chain V region

[0042] In the present invention, the H chain V region derived from an antibody recognizes TPO receptor and oligomerizes, for example, dimerizes through crosslinking said molecule, and thereby transduces a signal into the cells. The H chain V region of the invention includes H chain V regions derived from a mammal (e.g. human, mouse, rat, bovine, sheep, ape etc.) and H chain V regions having partially modified amino acid sequences of the H chain V regions. More preferable is a humanized H chain V region containing FR of H chain V region of a human monoclonal antibody and CDR of H chain V region of a mouse monoclonal antibody. Also preferable is an H chain V region having an amino acid sequence derived from a human, which can be produced by recombination technique. The H chain V region of the invention may be a fragment of aforementioned H chain V region, which fragment preserves the antigen binding capacity.

L chain V region

[0043] In the present invention, the L chain V region recognizes TPO receptor and oligomerizes, for example, dimerizes through crosslinking said molecule, and thereby transduces a signal into the cells. The L chain V region of the invention includes L chain V regions derived from a mammal (e.g. human, mouse, rat, bovine, sheep, ape etc.) and L chain V regions having partially modified amino acid sequences of the L chain V regions. More preferable is a humanized L chain V region containing FR of L chain V region of human monoclonal antibody and CDR of L chain V region of mouse monoclonal antibodies. Also preferable is an L chain V region having an amino acid sequence derived from a human, which can be produced by recombination technique. The L chain V regions of the invention may be fragments of L chain V region, which fragments preserve the antigen binding capacity.

Complementarity determining region (CDR)

[0044] Each V region of L chain and H chain forms an antigen-binding site. The variable region of the L and H chains is composed of comparatively conserved four common framework regions linked to three hypervariable regions or complementarity determining regions (CDR) (Kabat, E.A. et al., "Sequences of Protein of Immunological Interest", US Dept. Health and Human Services, 1983).

[0045] Major portions in the four framework regions (FRs) form β -sheet structures and thus three CDRs form a loop. CDRs may form a part of the β -sheet structure in certain cases. The three CDRs are held sterically close position to each other by FR, which contributes to the formation of the antigen-binding site together with three CDRs.

[0046] These CDRs can be identified by comparing the amino acid sequence of V region of the obtained antibody with known amino acid sequences of V regions of known antibodies according to the empirical rule in Kabat, E.A. et al., "Sequences of Protein of Immunological Interest". Single chain Fv

[0047] A single chain Fv is a polypeptide monomer comprising an H chain V region and an L chain V region linked each other which are derived from antibodies. The resulting single chain Fvs contain variable regions of the original antibodies and preserve the complementarity determining region thereof, and therefore the single chain Fvs bind to the antigen by the same specificity as that of the original antibodies (JP-Appl. 11-63557). A part of the variable region and/or CDR of the single chain Fv of the invention or a part of the amino acid sequence thereof may be partially altered, for example, deleted, replaced or added. The H chain V region and L chain V region composing the single chain Fv of the invention are mentioned before and may be linked directly or through a linker, preferably a peptide linker. The constitution of the single chain Fv may be [H chain V region]-[L chain V region] or [L chain V region]-[H chain V region].

[0048] In the present invention, it is possible to make the single chain Fv to form a dimer, a trimer or a tetramer, from which the modified antibody of the invention can be formed.

Single chain modified antibody

[0048] The single chain modified antibodies of the present invention comprising two or more H chain V regions and two or more L chain V regions, preferably each two to four, especially preferable each two, comprise two or more H chain V regions and L chain V regions as mentioned above. Each region of the peptide should be arranged such that the modified single chain antibody forms a specific steric structure, concretely mimicking a steric structure formed by the dimer of single chain Fv. For instance, the V regions are arranged in the order of the following manner:

[H chain V region]-[L chain V region]-[H chain V region]-[L chain V region]; or
 [L chain V region]-[H chain V region]-[L chain V region]-[H chain V region],

wherein these regions are connected through a peptide linker, respectively.

Linker

[0049] In this invention, the linkers for the connection between the H chain V region and the L chain V region may be any peptide linker which can be introduced by the genetic engineering procedure or any linker chemically synthesized. For instance, linkers disclosed in literatures, e.g. Protein Engineering, 9(3), 299-305, 1996 may be used in the invention. These linkers can be the same or different in the same molecule. If peptide linkers are required, the following are cited as example linkers:

Ser
 Gly-Ser
 Gly-Gly-Ser
 Ser-Gly-Gly
 Gly-Gly-Gly-Ser
 Ser-Gly-Gly-Gly
 Gly-Gly-Gly-Gly-Ser
 Ser-Gly-Gly-Gly-Gly
 Gly-Gly-Gly-Gly-Gly-Ser
 Ser-Gly-Gly-Gly-Gly-Gly
 Gly-Gly-Gly-Gly-Gly-Gly-Ser
 Ser-Gly-Gly-Gly-Gly-Gly-Gly
 (Gly-Gly-Gly-Gly-Ser)_n and
 (Ser-Gly-Gly-Gly-Gly)_n

wherein n is an integer not less than one. Preferable length of the linker peptide varies dependent upon the receptor to be the antigen, in the case of single chain Fvs, the range of 1 to 20 amino acids is normally preferable. In the case of single chain modified antibodies comprising two or more H chain V regions and two or more L chain V regions, the peptide linkers connecting those forming the same antigen binding site comprising [H chain V region]-[L chain V region] (or [L chain V region]-[H chain V region]) have lengths of 1 - 30 amino acids, preferably 1 - 20 amino acids, more preferably 3 - 18 amino acids. The peptide linkers connecting those not forming the same antigen biding site comprising [H chain V region]-[L chain V region] or ([L chain V region]-[H chain V region]) have lengths of 1 - 40 amino acids, preferably 3 - 30 amino acids, more preferably 5 - 20 amino acids. The method for introducing those linkers will be

described in the explanation for DNA construction coding for modified antibodies of the invention.

[0050] The chemically synthesized linkers, i.e. the chemical crosslinking agents, according to the invention can be any linkers conventionally employed for the linkage of peptides. Examples of the linkers may include N-hydroxy succinimide (NHS), disuccinimidyl suberate (DSS), bis(sulfosuccinimidyl)suberate (BS³), dithiobis(succinimidyl propionate) (DSP), dithiobis(sulfosuccinimidyl propionate) (DTSSP), ethylene glycolbis(succinimidyl succinate) (EGS), ethylene glycolbis (sulfosuccinimidyl succinate) (sulfo-EGS), disuccinimidyl tartrate (DST), disulfosuccinimidyl tartrate (sulfo-DST), bis [2- (succinimido oxy carbonyloxy) ethyl]sulfone (BSOCOES), bis[2-(sulfosuccinimido oxy carbonyloxy) ethyl]sulfone (sulfo-BSOCOES) or the like. These are commercially available. It is preferable for the chemically synthesized linkers to have the length equivalent to that of peptide linkers.

[0051] To form a dimer of the single chain Fv it is preferable to select a linker suitable to dimerize in the solution such as culture medium more than 20%, preferably more than 50%, more preferably more than 80%, most preferably more than 90% of the single chain Fv produced in the host cells. Specifically, preferable is a linker composed of 2 to 12 amino acids, preferably 3 to 10 amino acids or other linkers corresponding thereto.

15 Preparation of modified antibodies

[0052] The modified antibodies can be produced by connecting, through the aforementioned linker, an H chain V region and an L chain V region derived from known or novel antibodies specifically binding to TPO receptor. As examples of the single chain Fvs are cited those having H chain V region and L chain V region of antibody 12B5 and antibody 20 12E10 described in WO99/10494. As examples of the modified antibodies of the invention having two or more H chain V regions and two or more L chain V regions are cited sc12B5 dimer (linker: 15 amino acids), sc12E10 dimer (linker: 15 amino acids), db12B5 dimer (linker: 5 amino acids), db12E10 dimer (linker: 5 amino acids), sc12B5sc(FV)₂ and sc12E10sc(FV)₂ which contain H chain V regions and L chain V regions derived from the above-mentioned monoclonal antibodies.

[0053] For the preparation of the modified antibodies, a signal peptide may be attached to its N-terminal if the polypeptide is desired to be a secretory peptide. A well-known amino acid sequence useful for the purification of polypeptide such as the FLAG sequence may be attached for the efficient purification of the polypeptide. In this case a dimer can be formed by using anti-FLAG antibody.

[0054] For the preparation of the modified antibody of the invention, it is necessary to obtain a DNA, i.e. a DNA encoding the single chain Fv or a DNA' encoding reconstructed single chain polypeptide. These DNAs, especially for sc12B5, db12B5, sc12E10 and/or db12E10 are obtainable from the DNAs encoding the H chain V regions and the L chain V regions derived from said Fvs. They are also obtainable by polymerase chain reaction (PCR) method using those DNAs as a template and amplifying the part of DNA contained therein encoding desired amino acid sequence with the aid of a pair of primers corresponding to both ends thereof.

[0055] In the case where each V region having partially modified amino acid sequence is desired, the V regions in which one or some amino acids are modified, i.e. deleted, replaced or added can be obtained by a procedure known in the art using PCR. A part of the amino acid sequence in the V region is preferably modified by the PCR known in the art in order to prepare the modified antibody which is sufficiently active against the specific antigen.

[0056] For the determination of primers for the PCR amplification, the types of H chain and L chain, if a monoclonal antibody is used as a starting material, are determined by a typing method known in the technical field.

[0057] For the amplification of the L chain V regions of antibody 12B5 and antibody 12E10 by PCR, 5'-end and 3'-end oligonucleotide primers are decided as aforementioned. In the same manner, 5'-end and 3'-end oligonucleotide primers are decided for the amplification of the H chain V regions of antibody 12B5 and antibody 12E10.

[0058] In embodiments of the invention, the 5'-end primers which contain a sequence "GANTC" providing the restriction enzyme Hinf I recognition site at the neighborhood of 5'-terminal thereof are used and the 3'-end primers which contain a nucleotide sequence "CCCGGG" providing the XmaI recognition site at the neighborhood of 5'-terminal thereof are used. Other restriction enzyme recognition site may be used instead of these sites as long as they are used for subcloning a desired DNA fragment into a cloning vector.

[0059] Specifically designed PCR primers are employed to provide suitable nucleotide sequences at 5'-end and 3'-end of the cDNAs encoding the V regions of the antibodies 12B5 and 12E10 so that the cDNAs are readily inserted into an expression vector and appropriately function in the expression vector (e.g. this invention devises to increase transcription efficiency by inserting Kozak sequence). The V regions of the antibodies 12B5 and 12E10 obtained by amplifying by PCR using these primers are inserted into HEF expression vector containing the desired human C region (see WO92/19759). The cloned DNAs can be sequenced by using any conventional process, for example, by the automatic DNA sequencer (Applied Biosystems).

[0060] A linker such as a peptide linker can be introduced into the modified antibody of the invention in the following manner. Primers which have partially complementary sequence with the primers for the H chain V regions and the L chain V regions as described above and which code for the N-terminal or the C-terminal of the linker are designed.

Then, the PCR procedure can be carried out using these primers to prepare a DNA encoding the peptide linker having desired amino acid sequence and length. The DNAs encoding the H chain V region and the L chain V region can be connected through the resulting DNA to produce the DNA encoding the modified antibody of the invention which has the desired peptide linker. Once the DNA encoding one of the modified antibodies is prepared, the DNAs encoding the 5 modified antibodies with or without the desired peptide linker can readily be produced by designing various primers for the linker and then carrying out the PCR using the primers and the aforementioned DNA as a template.

[0061] Each V region of the modified antibody of the present invention can be humanized by using conventional techniques (e.g. Sato, K. et al., Cancer Res., 53, 1-6 (1993)). Once a DNA encoding each of humanized Fvs is prepared, a humanized single chain Fv, a fragment of the humanized single chain Fv, a humanized monoclonal antibody and a 10 fragment of the humanized monoclonal antibody can readily be produced according to conventional methods. Preferably, amino acid sequences of the V regions thereof may be partially modified, if necessary.

[0062] Furthermore, a DNA derived from other mammalian origin, for example a DNA encoding each of V regions of human antibody, can be produced in the same manner as used to produce DNA encoding the H chain V region and the L chain V region derived from mouse by conventional methods as mentioned in the above. The resulting DNA can be used to prepare an H chain V region and an L chain V region of other mammal, especially derived from human 15 antibody, a single chain Fv derived from human and a fragment thereof, and a monoclonal antibody of human origin and a fragment thereof.

[0063] When the modified antibodies of the invention is bi-specific modified antibodies, they can be produced by known methods (for example, the method described in W09413804).

[0064] As mentioned above, when the aimed DNAs encoding the V regions of the modified antibodies and the V 20 regions of the humanized modified antibodies are prepared, the expression vectors containing them and hosts transformed with the vectors can be obtained according to conventional methods. Further, the hosts can be cultured according to a conventional method to produce the reconstructed single chain Fv, the reconstructed humanized single chain Fv, the humanized monoclonal antibodies and fragments thereof. They can be isolated from cells or a medium 25 and can be purified into a homogeneous mass. For this purpose any isolation and purification methods conventionally used for proteins, e.g. chromatography, ultra-filtration, salting-out and dialysis, may be employed in combination, if necessary, without limitation thereto..

[0065] When the reconstructed single chain Fv of the present invention is produced by culturing an animal cell such 30 as COS7 cells or CHO cells, preferably CHO cells, in a serum-free medium, the dimer of said single chain Fv formed in the medium can be stably recovered and purified in a high yield. Thus purified dimer can be stably preserved for a long period. The serum-free medium employed in the invention may be any medium conventionally used for the production of a recombinant protein without limit thereto.

[0066] For the production of the modified antibodies of the present invention, any expression systems can be employed, for example, eukaryotic cells such as animal cells, e.g., established mammalian cell lines, filamentous fungi 35 and yeast, and prokaryotic cells such as bacterial cells e.g., E. coli. Preferably, the modified antibodies of the invention are expressed in mammalian cells, for example COS7 cells or CHO cells.

[0067] In these cases, conventional promoters useful for the expression in mammalian cells can be used. Preferably, 40 human cytomegalovirus (HCMV) immediate early promoter is used. Expression vectors containing the HCMV promoter include HCMV-VH-HCy 1, HCMV-VL-HCK and the like which are derived from pSV2neo (W092/19759).

[0068] Additionally, other promoters for gene expression in mammal cell which may be used in the invention include 45 virus promoters derived form retrovirus, polyoma virus, adenovirus and simian virus 40 (SV40) and promoters derived from mammal such as human polypeptide-chain elongation factor-1 α (HEF-1 α). SV40 promoter can easily be used according to the method of Mulligan, R.C., et al. (Nature 277, 108-114 (1979)) and HEF-1 α promoter can also be used according to the methods of Mizushima, S. et al. (Nucleic Acids Research, 18, 5322 (1990)).

[0069] Replication origin (ori) which can be used in the invention includes ori derived from SV40, polyoma virus, adenovirus, bovine papilloma virus (BPV) and the like. An expression vector may contain, as a selection marker, phosphotransferase APH (3') II or I (neo) gene, thymidine kinase (TK) gene, E. coli xanthine-guanine phosphoribosyl transferase (Ecogpt) gene or dihydrofolate reductase (DHFR) gene.

[0070] The antigen-binding activity of the modified antibody prepared in the above can be evaluated by a conventional 50 method such as radio immunoassay (RIA), enzyme-linked immunosorbent assay (ELISA) or surface plasmon resonance. It can also be evaluated using the binding-inhibitory ability of original antibody as an index, for example in terms of the absence or presence of concentration-dependent inhibition of the binding of said monoclonal antibody to the antigen.

[0071] More in detail, animal cells transformed with an expression vector containing a DNA encoding the modified 55 antibody of the invention, e.g., COST7 cells or CHO cells, are cultured. The cultured cells and/or the supernatant of the medium or the modified antibody purified from them are used to determine the binding to antigen. As a control is used a supernatant of the culture medium in which cells transformed only with the expression vector were cultured. In the case of an antigen, for example, the antibody 12B5 and the antibody 12E10, a test sample of the modified antibody of

the invention or a supernatant of the control is added to Ba/F3 cells expressing human MPL and then an assay such as the flow cytometry is carried out to evaluate the antigen-binding activity.

[0072] In vitro evaluation of the signal transduction effect (for example, proliferation, differentiation-induction or growth stimulation of megakaryocyte, platelet production, or phosphorylation of TPO receptor protein) is performed in the following manner. A test sample of the above-mentioned modified antibody is added to the cells which are expressing the antibody or cells into which the gene for the antibody has been introduced, and is evaluated by the change caused by the signal transduction (for example, human MPL antigen-specific proliferation, measurement of protein phosphorylation, or expression of platelet-specific antigen) using conventional methods.

[0073] In vivo evaluation is carried out by administering a monoclonal antibody recognizing MPL, a modified antibody of the invention and PBS as control to mice, and evaluating the strength of the activity by the change of the amount of platelet in mouse serum.

[0074] As mentioned above the modified antibodies of the invention can be obtained by preparing modified antibodies which contain two or more H chain V regions and two or more L chain V regions and specifically bind to TPO receptor and screening the modified antibodies by in vivo or in vitro evaluation as mentioned in the above.

[0075] The modified antibodies of the invention, which comprises two or more H chain V regions and two or more L chain V regions, preferably each two to four, more preferably each two, may be a dimer of the single chain Fv comprising one H chain V region and one L chain V region, or a single chain polypeptide in which two or more H chain V regions and two or more L chain V regions are connected. It is considered that owing to such construction the peptide mimics three dimensional structure of TPO and therefore retains an excellent antigen-binding property and TPO agonist activity.

[0076] The modified antibodies of the invention have a remarkably lowered molecular size compared with parent antibody molecule (e.g. IgG), and, therefore, have a superior permeability into tissues and tumors and a higher activity than parent monoclonal antibody molecule. Therefore, the modified antibodies of the invention can efficiently transduce TPO signal into cells. The pharmaceutical preparations containing them are useful for treating platelet-reduction-related blood diseases and thrombocytopenia caused by chemotherapy for cancers or leukemia. It is further expected that the antibody of the invention can be used as a contrast agent by RI-labeling. The effect can be enhanced by attaching to a RI-compound or a toxin.

BEST MODE FOR WORKING THE INVENTION

[0077] The present invention will concretely be illustrated in reference to the following examples, which in no way limit the scope of the invention.

[0078] For illustrating the production process of the modified antibodies of the invention, examples of producing single chain Fvs are shown below. Mouse antibodies against human IAP, MABL-1 and MABL-2 were used in the examples of producing the modified antibodies. Hybridomas MABL-1 and MABL-2 producing them respectively were internationally deposited as FERM BP-6100 and FERM BP-6101 with the National Institute of Bioscience and Human Technology, Agency of Industrial Science and Technology, Minister of International Trade and Industry (1-3 Higasi 1-chome, Tsukuba-shi, Ibaraki-ken, Japan), an authorized depository for microorganisms, on September 11, 1997.

Examples

Example 1 (Cloning of DNAs encoding V region of mouse monoclonal antibodies to human IAP)

[0079] DNAs encoding variable regions of the mouse monoclonal antibodies to human IAP, MABL-1 and MABL-2, were cloned as follows.

1.1 Preparation of messenger RNA (mRNA)

[0080] mRNAs of the hybridomas MABL-1 and MABL-2 were obtained by using mRNA Purification Kit (Pharmacia Biotech).

1.2 Synthesis of double-stranded cDNA

[0081] Double-stranded cDNA was synthesized from about 1 µg of the mRNA using Marathon cDNA Amplification Kit (CLONTECH) and an adapter was linked thereto.

1.3 PCR Amplification of genes encoding variable regions of an antibody by

[0082] PCR was carried out using Thermal Cycler (PERKIN ELMER).

(1) Amplification of a gene coding for L chain V region of MABL-1

[0083] Primers used for the PCR method are Adapter Primer-1 (CLONTECH) shown in SEQ ID No. 1, which hybridizes to a partial sequence of the adapter, and MKC (Mouse Kappa Constant) primer (Bio/Technology, 9, 88-89, 1991) shown in SEQ ID No. 2, which hybridizes to the mouse kappa type L

chain V region.

[0084] 50 µl of the PCR solution contains 5 µl of 10 x PCR Buffer II, 2 mM MgCl₂, 0.16 mM dNTPs (dATP, dGTP, dCTP and dTTP), 2.5 units of a DNA polymerase, AmpliTaq Gold (PERKIN ELMER), 0.2 µM of the adapter primer of SEQ ID No. 1, 0.2 µM of the MKC primer of SEQ ID No. 2 and 0.1 µg of the double-stranded cDNA derived from MABL-1. The solution was preheated at 94°C of the initial temperature for 9 minutes and then heated at 94°C for 1 minute, at 60°C for 1 minute and at 72°C for 1 minute 20 seconds in order. This temperature cycle was repeated 35 times and then the reaction mixture was further heated at 72°C for 10 minutes.

(2) Amplification of cDNA encoding H chain V region of MABL-1

[0085] The Adapter Primer-1 shown in SEQ ID No. 1 and MHC-γ1 (Mouse Heavy Constant) primer (Bio/Technology, 9, 88-89, 1991) shown in SEQ ID No. 3 were used as primers for PCR.

[0086] The amplification of cDNA was performed according to the method of the amplification of the L chain V region gene, which was described in Example 1.3-(1), except for using 0.2 µM of the MHC-γ1 primer instead of 0.2 µM of the MKC primer.

(3) Amplification of cDNA encoding L chain V region of MABL-2

[0087] The Adapter Primer-1 of SEQ ID No. 1 and the MKC primer of SEQ ID No. 2 were used as primers for PCR.

[0088] The amplification of cDNA was carried out according to the method of the amplification of the L chain V region gene of MABL-1 which was described in Example 1.3-(1), except for using 0.1 µg of the double-stranded cDNA derived from MABL-2 instead of 0.1 µg of the double-stranded cDNA from MABL-1.

(4) Amplification of cDNA encoding H chain V region of MABL-2

[0089] The Adapter Primer-1 of SEQ ID No. 1 and MHC-γ2a primer (Bio/Technology, 9, 88-89, 1991) shown in SEQ ID No. 4 were used as primers for PCR.

[0090] The amplification of cDNA was performed according to the method of the amplification of the L chain V region gene, which was described in Example 1.3-(3), except for using 0.2 µM of the MHC-γ2a primer instead of 0.2 µM of the MKC primer.

1.4 Purification of PCR products

[0091] The DNA fragment amplified by PCR as described above was purified using the QIAquick PCR Purification Kit (QIAGEN) and dissolved in 10 mM Tris-HCl (pH 8.0) containing 1 mM EDTA.

1.5 Ligation and Transformation

[0092] About 140 ng of the DNA fragment comprising the gene encoding the mouse kappa type L chain V region derived from MABL-1 as prepared above was ligated with 50 ng of pGEM-T Easy vector (Promega) in the reaction buffer comprising 30 mM Tris-HCl (pH 7.8), 10 mM MgCl₂, 10 mM dithiothreitol, 1 mM ATP and 3 units of T4 DNA Ligase (Promega) at 15°C for 3 hours.

[0093] Then, 1 µl of the reaction mixture was added to 50 µl of *E. coli* DH5α competent cells (Toyobo Inc.) and the cells were stored on ice for 30 minutes, incubated at 42°C for 1 minute and stored on ice for 2 minutes again. 100 µl of SOC medium (GIBCO BRL) was added. The cells of *E. coli* were plated on LB (Molecular Cloning: A Laboratory Manual, Sambrook et al., Cold Spring Harbor Laboratory Press, 1989) agar medium containing 100 µg/ml of ampicillin (SIGMA) and cultured at 37°C overnight to obtain the transformant of *E. coli*.

[0094] The transformant was cultured in 3 ml of LB medium containing 50 µg/ml of ampicillin at 37°C overnight and the plasmid DNA was prepared from the culture using the QIAprep Spin Miniprep Kit (QIAGEN).

[0095] The resulting plasmid comprising the gene encoding the mouse kappa type L chain V region derived from the hybridoma MABL-1 was designated as pGEM-M1L.

[0096] According to the same manner as described above, a plasmid comprising the gene encoding the mouse H chain V region derived from the hybridoma MABL-1 was prepared from the purified DNA fragment and designated as pGEM-M1H.

[0097] A plasmid comprising the gene encoding the mouse kappa type L chain V region derived from the hybridoma MABL-2 was prepared from the purified DNA fragment and designated as pGEM-M2L.

[0098] A plasmid comprising the gene encoding the mouse H chain V region derived from the hybridoma MABL-2 was prepared from the purified DNA fragment and designated as pGEM-M2H.

Example 2 (DNA Sequencing)

[0099] The nucleotide sequence of the cDNA encoding region in the aforementioned plasmids was determined using Auto DNA Sequencer (Applied Biosystem) and ABI PRISM Dye Terminator Cycle Sequencing Ready Reaction Kit (Applied Biosystem) according to the manufacturer's protocol.

[0100] The nucleotide sequence of the gene encoding the L chain V region from the mouse antibody MABL-1, which is included in the plasmid pGEM-M1L, is shown in SEQ ID No. 5.

[0101] The nucleotide sequence of the gene encoding the H chain V region from the mouse antibody MABL-1, which is included in the plasmid pGEM-M1H is shown in SEQ ID No. 6.

[0102] The nucleotide sequence of the gene encoding the L chain V region from the mouse antibody MABL-2, which is included in the plasmid pGEM-M2L, is shown in SEQ ID No. 7.

[0103] The nucleotide sequence of the gene encoding the H chain V region from the mouse antibody MABL-2, which is included in the plasmid pGEM-M2H, is shown in SEQ ID No. 8.

Example 3 (Determination of CDR)

[0104] The V regions of L chain and H chain generally have a similarity in their structures and each four framework regions therein are linked by three hypervariable regions, i.e., complementarity determining regions (CDR). An amino acid sequence of the framework is relatively well conserved, while an amino acid sequence of CDR has extremely high variation (Kabat, E.A., et al., "Sequences of Proteins of Immunological Interest", US Dept. Health and Human Services, 1983).

[0105] On the basis of these facts, the amino acid sequences of the variable regions from the mouse monoclonal antibodies to human IAP were applied to the database of amino acid sequences of the antibodies made by Kabat et al. to investigate the homology. The CDR regions were determined based on the homology as shown in Table 1.

Table 1

Plasmid	SEQ ID No.	CDR(1)	CDR(2)	CDR(3)
pGEM-M1L	5	43-58	74-80	113-121
pGEM-M1H	6	50-54	69-85	118-125
pGEM-M2L	7	43-58	74-80	113-121
pGEM-M2H	8	50-54	69-85	118-125

Example 4 (Identification of Cloned cDNA Expression

(Preparation of Chimera MABL-1 antibody and Chimera MABL-2 antibody.)

4.1 Preparation of vectors expressing chimera MABL-1 antibody

[0106] cDNA clones, pGEM-M1L and pGEM-M1H, encoding the V regions of the L chain and the H chain of the mouse antibody MABL-1, respectively, were modified by the PCR method and introduced into the HEF expression vector (W092/19759) to prepare vectors expressing chimera MABL-1 antibody.

[0107] A forward primer MLS (SEQ ID No. 9) for the L chain V region and a forward primer MHS (SEQ ID No. 10) for the H chain V region were designed to hybridize to a DNA encoding the beginning of the leader sequence of each V region and to contain the Kozak consensus sequence (J. Mol. Biol., 196, 947-950, 1987) and HindIII restriction enzyme site. A reverse primer MLAS (SEQ ID No. 11) for the L chain V region and a reverse primer MHAS (SEQ ID No. 12) for the H chain V region were designed to hybridize to a DNA encoding the end of the J region and to contain the splice donor sequence and BamHI restriction enzyme site.

[0108] 100 µl of a PCR solution comprising 10 µl of 10 × PCR Buffer II, 2 mM MgCl₂, 0.16 mM dNTPs (dATP, dGTP,

dCTP and dTTP), 5 units of DNA polymerase AmpliTaq Gold, 0.4 μ M each of primers and 8 ng of the template DNA (pGEM-M1L or pGEM-M1H was preheated at 94°C of the initial temperature for 9 minutes and then heated at 94°C for 1 minute, at 60°C for 1 minute and at 72°C for 1 minute 20 seconds in order. This temperature cycle was repeated 35 times and then the reaction mixture was further heated at 72°C for 10 minutes.

[0109] The PCR product was purified using the QIAquick PCR Purification Kit (QIAGEN) and then digested with HindIII and BamHI. The product from the L chain V region was cloned into the HEF expression vector, HEF-K and the product from the H chain V region was cloned into the HEF expression vector, HEF- γ . After DNA sequencing, plasmids containing a DNA fragment with a correct DNA sequence are designated as HEF-M1L and HEF-M1H, respectively.

4.2 Preparation of vectors expressing chimera MABL-2 antibodies

[0110] Modification and cloning of cDNA were performed in the same manner described in Example 4.1 except for using pGEM-M2L and pGEM-M2H as template DNA instead of pGEM-M1L and pGEM-M1H. After DNA sequencing, plasmids containing DNA fragments with correct DNA sequences are designated as HEF-M2L and HEF-M2H, respectively.

4.3 Transfection to COS7 cells

[0111] The aforementioned expression vectors were tested in COS7 cells to observe the transient expression of the chimera MABL-1 and MABL-2 antibodies.

(1) Transfection with genes for the chimera MABL-1 antibody

[0112] COS7 cells were co-transformed with the HEF-M1L and HEF-M1H vectors by electroporation using the Gene Pulser apparatus (BioRad). Each DNA (10 μ g) and 0.8 ml of PBS with 1×10^7 cells/ml were added to a cuvette. The mixture was treated with pulse at 1.5 kV, 25 μ F of electric capacity.

[0113] After the restoration for 10 minutes at a room temperature, the electroporated cells were transferred into DMEM culture medium (GIBCO BRL) containing 10% γ -globulin-free fetal bovine serum. After culturing for 72 hours, the supernatant was collected, centrifuged to remove cell fragments and recovered.

(2) Transfection with genes coding for the chimera MABL-2 antibody

[0114] The co-transfection to COS7 cells with the genes coding for the chimera MABL-2 antibody was carried out in the same manner as described in Example 4.3-(1) except for using the HEF-M2L and HEF-M2H vectors instead of the HEF-M1L and HEF-M1H vectors. The supernatant was recovered in the same manner.

4.4 Flow cytometry

[0115] Flow cytometry was performed using the aforementioned culture supernatant of COS7 cells to measure binding to the antigen. The culture supernatant of the COS7 cells expressing the chimera MABL-1 antibody or the COS7 cells expressing the chimera MABL-2 antibody, or human IgG antibody (SIGMA) as a control was added to 4×10^5 cells of mouse leukemia cell line L1210 expressing human IAP and incubated on ice. After washing, the FITC-labeled anti-human IgG antibody (Cappel) was added thereto. After incubating and washing, the fluorescence intensity thereof was measured using the FACScan apparatus (TECTON DICKINSON).

[0116] Since the chimera MABL-1 and MABL-2 antibodies were specifically bound to L1210 cells expressing human IAP, it is confirmed that these chimera antibodies have proper structures of the V regions of the mouse monoclonal antibodies MABL-1 and MABL-2, respectively (Figs. 1-3).

Example 5 (Preparation of reconstructed Single chain Fv (scFv) of the antibody MABL-1 and antibody MABL-2)

5.1 Preparation of reconstructed single chain Fv of antibody MABL-1

[0117] The reconstructed single chain Fv of antibody MABL-1 was prepared as follows. The H chain V region and the L chain V of antibody MABL-1, and a linker were respectively amplified by the PCR method and were connected to produce the reconstructed single chain Fv of antibody MABL-1. The production method is illustrated in Fig. 4. Six primers (A-F) were employed for the production of the single chain Fv of antibody MABL-1. Primers A, C and E have a sense sequence and primers B, D and F have an antisense sequence.

[0118] The forward primer VHS for the H chain V region (Primer A, SEQ ID No. 13) was designed to hybridize to a

DNA encoding the N-terminal of the H chain V region and to contain NcoI restriction enzyme recognition site. The reverse primer VHAS for H chain V region (Primer B, SEQ ID No. 14) was designed to hybridize to a DNA coding the C-terminal of the H chain V region and to overlap with the linker.

[0119] The forward primer LS for the linker (Primer C, SEQ ID No. 15) was designed to hybridize to a DNA encoding the N-terminal of the linker and to overlap with a DNA encoding the C-terminal of the H chain V region. The reverse primer LAS for the linker (Primer D, SEQ ID No. 16) was designed to hybridize to a DNA encoding the C-terminal of the linker and to overlap with a DNA encoding the N-terminal of the L chain V region.

[0120] The forward primer VLS for the L chain V region (Primer E, SEQ ID No. 17) was designed to hybridize to a DNA encoding the C-terminal of the linker and to overlap with a DNA encoding the N-terminal of the L chain V region. The reverse primer VLAS-FLAG for L chain V region (Primer F, SEQ ID No. 18) was designed to hybridize to a DNA encoding the C-terminal of the L chain V region and to have a sequence encoding the FLAG peptide (Hopp, T. P. et al., Bio/Technology, 6, 1204-1210, 1988), two stop codons and EcoRI restriction enzyme recognition site.

[0121] In the first PCR step, three reactions, A-B, C-D and E-F, were carried out and PCR products thereof were purified. Three PCR products obtained from the first PCR step were assembled by their complementarity. Then, the primers A and F were added and the full length DNA encoding the reconstructed single chain Fv of antibody MABL-1 was amplified (Second PCR). In the first PCR, the plasmid pGEM-M1H encoding the H chain V region of antibody MABL-1 (see Example 2), a plasmid pSC-DP1 which comprises a DNA sequence encoding a linker region comprising: Gly Gly Gly Gly Ser Gly Gly Ser Gly Gly Gly Ser (SEQ ID No. 19) (Huston, J.S., et al., Proc. Natl. Acad. Sci. USA, 85, 5879-5883, 1988) and the plasmid pGEM-M1L encoding the L chain V region of antibody MABL-1 (see Example 2) were employed as template, respectively.

[0122] 50 µl of the solution for the first PCR step comprises 5 µl of 10 × PCR Buffer II, 2 mM MgCl₂, 0.16 mM dNTPs, 2.5 units of DNA polymerase, AmpliTaq Gold (PERKIN ELMER), 0.4 µM each of primers and 5 ng each of template DNA. The PCR solution was preheated at 94°C of the initial temperature for 9 minutes and then heated at 94°C for 1 minute, at 65°C for 1 minute and at 72°C for 1 minute and 20 seconds in order. This temperature cycle was repeated 35 times and then the reaction mixture was further heated at 72°C for 7 minutes.

[0123] The PCR products A-B (371bp), C-D (63bp) and E-F (384bp) were purified using the QIAquick PCR Purification Kit (QIAGEN) and were assembled in the second PCR. In the second PCR, 98 µl of a PCR solution comprising 120 ng of the first PCR product A-B, 20 ng of the PCR product C-D and 120 ng of the PCR product E-F, 10 µl of 10 × PCR Buffer II, 2mM MgCl₂, 0.16 mM dNTPs, 5 units of DNA polymerase AmpliTaq Gold (PERKIN ELMER) was preheated at 94°C of the initial temperature for 8 minutes and then heated at 94°C for 2 minutes, at 65°C for 2 minutes and at 72°C for 2 minutes in order. This temperature cycle was repeated twice and then 0.4 µM each of primers A and F were added into the reaction, respectively. The mixture was preheated at 94°C of the initial temperature for 1 minutes and then heated at 94°C for 1 minute, at 65°C for 1 minute and at 72°C for 1 minute and 20 seconds in order. This temperature cycle was repeated 35 times and then the reaction mixture was further heated at 72°C for 7 minutes.

[0124] A DNA fragment of 843 bp produced by the second PCR was purified and digested by NcoI and EcoRI. The resultant DNA fragment was cloned into pSCFVT7 vector. The expression vector pSCFVT7 contains a pelB signal sequence suitable for *E. coli* periplasmic expression system (Lei, S.P., et al., J. Bacteriology, 169, 4379-4383, 1987). After the DNA sequencing, the plasmid containing the DNA fragment encoding correct amino acid sequence of the reconstructed single chain Fv of antibody MABL-1 is designated as "pscM1" (see Fig. 5). The nucleotide sequence and the amino acid sequence of the reconstructed single chain Fv of antibody MABL-1 contained in the plasmid pscM1 are shown in SEQ ID No. 20.

[0125] The pscM1 vector was modified by the PCR method to prepare a vector expressing the reconstructed single chain Fv of antibody MABL-1 in mammalian cells. The resultant DNA fragment was introduced into pCHO1 expression vector. This expression vector, pCHO1, was constructed by digesting DHFR-ΔE-rvH-PM1-f (W092/19759) with EcoRI and SmaI to eliminate the antibody gene and connecting the EcoRI-NotI-BamHI Adapter (Takara Shuzo) thereto.

[0126] As a forward primer for PCR, Sal-VHS primer shown in SEQ ID No. 21 was designed to hybridize to a DNA encoding the N-terminal of the H chain V region and to contain SalI restriction enzyme recognition site. As a reverse primer for PCR, FRHlanti primer shown in SEQ ID No. 22 was designed to hybridize to a DNA encoding the end of the first framework sequence.

[0127] 100 µl of PCR solution comprising 10 µl of 10 × PCR Buffer II, 2 mM MgCl₂, 0.16 mM dNTPs, 5 units of the DNA polymerase, AmpliTaq Gold, 0.4 µl M each of primer and 8 ng of the template DNA (pscM1) was preheated at 95°C of the initial temperature for 9 minutes and then heated at 95°C for 1 minute, at 60°C for 1 minute and at 72°C for 1 minute and 20 seconds in order. This temperature cycle was repeated 35 times and then the reaction mixture was further heated at 72°C for 7 minutes.

[0128] The PCR product was purified using the QIAquick PCR Purification Kit (QIAGEN) and digested by SalI and MboII to obtain a DNA fragment encoding the N-terminal of the reconstructed single chain Fv of antibody MABL-1. The pscM1 vector was digested by MboII and EcoRI to obtain a DNA fragment encoding the C-terminal of the reconstructed single chain Fv of antibody MABL-1. The SalI-MboII DNA fragment and the MboII-EcoRI DNA fragment were cloned

into pCHO1-Igs vector. After DNA sequencing, the plasmid comprising the desired DNA sequence was designated as "pCHOM1" (see Fig. 6). The expression vector, pCHO1-Igs, contains a mouse IgG1 signal sequence suitable for the secretion-expression system in mammalian cells (Nature, 322, 323-327, 1988). The nucleotide sequence and the amino acid sequence of the reconstructed single chain Fv of antibody MABL-1 contained in the plasmid pCHOM1 are shown in SEQ ID No. 23.

5.2 Preparation of reconstructed single chain Fv of antibody MABL-2

[0129] The reconstructed single chain Fv of antibody MABL-2 was prepared in accordance with the aforementioned Example 5.1. Employed in the first PCR step were plasmid pGEM-M2H encoding the H chain V region of MABL-2 (see Example 2) instead of pGEM-M1H and plasmid pGEM-M2L encoding the L chain V region of MABL-2 (see Example 2) instead of pGEM-M1L, to obtain a plasmid pscM2 which comprises a DNA fragment encoding the desired amino acid sequence of the single chain Fv of antibody MABL-2. The nucleotide sequence and the amino acid sequence of the reconstructed single chain Fv of antibody MABL-2 contained in the plasmid pscM2 are shown in SEQ ID No. 24.

[0130] The pscM2 vector was modified by the PCR method to prepare a vector, pCHOM2, for the expression in mammalian cells which contains the DNA fragment encoding the correct amino acid sequence of reconstructed the single chain Fv. of antibody MABL-2. The nucleotide sequence and the amino acid sequence of the reconstructed single chain Fv of antibody MABL-2 contained in the plasmid pCHOM2 are shown in SEQ ID No. 25.

20 5.3 Transfection to COS7 cells

[0131] The pCHOM2 vector was tested in COS7 cells to observe the transient expression of the reconstructed single chain Fv of antibody MABL-2.

[0132] The COS7 cells were transformed with the pCHOM2 vector by electroporation using the Gene Pulser apparatus (BioRad). The DNA (10 µg) and 0.8 ml of PBS with 1×10^7 cells/ml were added to a cuvette. The mixture was treated with pulse at 1.5 kV, 25 µF of electric capacity.

[0133] After the restoration for 10 minutes at a room temperature, the electroporated cells were transferred into IMDM culture medium (GIBCO BRL) containing 10% fetal bovine serum. After culturing for 72 hours, the supernatant was collected, centrifuged to remove cell fragments and recovered.

30 5.4 Detection of the reconstructed single chain Fv of antibody MABL-2 in culture supernatant of COS7 cells

[0134] The existence of the single chain Fv of antibody MABL-2 in the culture supernatant of COS7 cells which had been transfected with the pCHOM2 vector was confirmed by the Western Blotting method.

[0135] The culture supernatant of COS7 cells transfected with the pCHOM2 vector and the culture supernatant of COS7 cells transfected with the pCHO1 as a control were subjected to SDS electrophoresis and transferred to REINFORCED NC membrane (Schleicher & Schuell). The membrane was blocked with 5% skim milk (Morinaga Nyu-gyo), washed with 0.05% Tween 20-PBS and mixed with an anti-FLAG antibody (SIGMA). The membrane was incubated at room temperature, washed and mixed with alkaline phosphatase-conjugated mouse IgG antibody (Zymed). After incubating and washing at room temperature, the substrate solution (Kirkegaard Perry Laboratories) was added to develop color (Fig. 7).

[0136] A FLAG-peptide-specific protein was detected only in the culture supernatant of the pCHOM2 vector-introduced COS7 cells and thus it is confirmed that the reconstructed single chain Fv of antibody MABL-2 was secreted in this culture supernatant.

45 5.5 Flow cytometry

[0137] Flow cytometry was performed using the aforementioned COS7 cells culture supernatant to measure the binding to the antigen. The culture supernatant of the COS7 cells expressing the reconstructed single chain Fv of antibody MABL-2 or the culture supernatant of COS7 cells transformed with pCHO1 vector as a control was added to 2×10^5 cells of the mouse leukemia cell line L1210 expressing human Integrin Associated Protein (IAP) or the cell line L1210 transformed with pCOS1 as a control. After incubating on ice and washing, the mouse anti-FLAG antibody (SIGMA) was added. Then the cells were incubated and washed. Then, the FITC labeled anti-mouse IgG antibody (BECTON DICKINSON) was added thereto and the cells were incubated and washed again. Subsequently, the fluorescence intensity was measured using the FACScan apparatus (BECTON DICKINSON).

[0138] Since the single chain Fv of antibody MABL-2 was specifically bound to L1210 cells expressing human IAP, it is confirmed that the reconstructed single chain Fv of antibody MABL-2 has an affinity to human Integrin Associated Protein (IAP) (see Figs. 8-11).

5.6 Competitive ELISA

[0139] The binding activity of the reconstructed single chain Fv of antibody MABL-2 was measured based on the inhibiting activity against the binding of mouse monoclonal antibodies to the antigen.

[0140] The anti-FLAG antibody adjusted to 1 µg/ml was added to each well on 96-well plate and incubated at 37°C for 2 hours. After washing, blocking was performed with 1% BSA-PBS. After incubating and washing at a room temperature, the culture supernatant of COS7 cells into which the secretion-type human IAP antigen gene (SEQ ID No. 26) had been introduced was diluted with PBS into twofold volume and added to each well. After incubating and washing at a room temperature, a mixture of 50 µl of the biotinized MABL-2 antibody adjusted to 100 ng/ml and 50 µl of sequentially diluted supernatant of the COS7 cells expressing the reconstructed single chain Fv of antibody MABL-2 were added into each well. After incubating and washing at a room temperature, the alkaline phosphatase-conjugated streptoavidin (Zymed) was added into each well. After incubating and washing at a room temperature, the substrate solution (SIGMA) was added and absorbance of the reaction mixture in each well was measured at 405 nm.

[0141] The results revealed that the reconstructed single chain Fv of antibody MABL-2 (MABL2-scFv) evidently inhibited concentration-dependently the binding of the mouse antibody MABL-2 to human IAP antigen in comparison with the culture supernatant of the PCHO1-introduced COS7 cells as a control (Fig. 12). Accordingly, it is suggested that the reconstructed single chain Fv of antibody MABL-2 has the correct structure of each of the V regions from the mouse monoclonal antibody MABL-2.

5.7 Apoptosis-inducing Effect in vitro

[0142] An apoptosis-inducing action of the reconstructed single chain Fv of antibody MABL-2 was examined by Annexin-V staining (Boehringer Mannheim) using the L1210 cells transfected with human IAP gene, the L1210 cells transfected with the pCOS1 vector as a control and CCRF-CEM cells.

[0143] To each 1×10^5 cells of the above cells was added the culture supernatant of the COS7 cells expressing the reconstructed single chain Fv of antibody MABL-2 or the culture supernatant of COS7 cells transfected with the pCHO1 vector as a control at 50% final concentration and the mixtures were cultured for 24 hours. Then, the Annexin-V staining was performed and the fluorescence intensity was measured using the FACScan apparatus (BECTON DICKINSON).

[0144] Results of the Annexin-V staining are shown in Figs. 13-18, respectively. Dots in the left-lower region represent living cells and dots in the right-lower region represent cells at the early stage of apoptosis and dots in the right-upper region represent cells at the late stage of apoptosis. The results show that the reconstructed single chain Fv of antibody MABL-2 (MABL2-scFv) remarkably induced cell death of L1210 cells specific to human IAP antigen (Figs. 13-16) and that the reconstructed single chain Fv also induced remarkable cell death of CCRF-CEM cells in comparison with the control (Figs. 17-18).

5.8 Expression of MABL-2 derived single chain Fv in CHO cells

[0145] CHO cells were transfected with the pCHOM2 vector to establish a CHO cell line which constantly expresses the single chain Fv (polypeptide) derived from the antibody MABL-2.

[0146] CHO cells were transformed with the pCHOM2 vector by the electroporation using the Gene Pulser apparatus (BioRad). A mixture of DNA (10 µg) and 0.7 ml of PBS with CHO cells (1×10^7 cells/ml) was added to a cuvette. The mixture was treated with pulse at 1.5 kV, 25 µF of electric capacity. After the restoration for 10 minutes at a room temperature, the electroporated cells were transferred into nucleic acid free α-MEM medium (GIBCO BRL) containing 10% fetal bovine serum and cultured. The expression of desired protein in the resultant clones was confirmed by SDS-PAGE and a clone with a high expression level was selected as a cell line producing the single chain Fv derived from the antibody MABL-2. The cell line was cultured in serum-free medium CHO-S-SFM II (GIBCO BRL) containing 10 nM methotrexate (SIGMA). Then, the culture supernatant was collected, centrifuged to remove cell fragments and recovered.

5.9 Purification of MABL-2 derived single chain Fv produced in CHO cells

[0147] The culture supernatant of the CHO cell line expressing the single chain Fv obtained in Example 5.8 was concentrated up to twenty times using a cartridge for the artificial dialysis (PAN130SF, ASAHI MEDICALS). The concentrated solution was stored at -20°C and thawed on purification.

[0148] Purification of the single chain Fv from the culture supernatant of the CHO cells was performed using three kinds of chromatography, i.e., Blue-sepharose, a hydroxyapatite and a gel filtration.

(1) Blue-sepharose column chromatography

[0149] The concentrated supernatant was diluted to ten times with 20 mM acetate buffer (pH 6.0) and centrifuged to remove insoluble materials ($10000 \times \text{rpm}$, 30 minutes). The supernatant was applied onto a Blue-sepharose column (20 ml) equilibrated with the same buffer. After washing the column with the same buffer, proteins adsorbed in the column were eluted by a stepwise gradient of NaCl in the same buffer, 0.1, 0.2, 0.3, 0.5 and up to 1.0 M. The pass-through fraction and each eluted fraction were analyzed by SDS-PAGE. The fractions in which the single chain Fv were confirmed (the fractions eluted at 0.1 to 0.3M NaCl) were pooled and concentrated up to approximately 20 times using CentriPrep-10 (AMICON).

(2) Hydroxyapatite

[0150] The concentrated solution obtained in (1) was diluted to 10 times with 10 mM phosphate buffer (pH 7.0) and applied onto the hydroxyapatite column (20 ml, BIORAD). The column was washed with 60 ml of 10 mM phosphate buffer (pH 7.0). Then, proteins adsorbed in the column were eluted by a linear gradient of sodium phosphate buffer up to 200 mM (see Fig. 19). The analysis of each fraction by SDS-PAGE confirmed the single chain Fv in fraction A and fraction B.

(3) Gel filtration

[0151] Each of fractions A and B in (2) was separately concentrated with CentriPrep-10 and applied onto TSKgel G3000SWG column ($21.5 \times 600 \text{ mm}$) equilibrated with 20 mM acetate buffer (pH 6.0) containing 0.15 M NaCl. Chromatograms are shown in Fig. 20. The analysis of the fractions by SDS-PAGE confirmed that both major peaks (AI and BI) are of desired single chain Fv. In the gel filtration analysis, the fraction A was eluted at 36 kDa of apparent molecular weight and the fraction B was eluted at 76 kDa. The purified single chain Fvs (AI, BI) were analyzed with 15% SDS polyacrylamide gel. Samples were treated in the absence or presence of a reductant and the electrophoresis was carried out in accordance with the Laemmli's method. Then the protein was stained with Coomassie Brilliant Blue. As shown in Fig. 21, both AI and BI gave a single band at 35 kDa of apparent molecular weight, regardless of the absence or presence of the reductant. From the above, it is concluded that AI is a monomer of the single chain Fv and BI is a non-covalently bound dimer of the single chain Fv. The gel filtration analysis of the fractions AI and BI with TSKgel G3000SW column ($7.5 \times 60 \text{ mm}$) revealed that a peak of the monomer is detected only in the fraction AI and a peak of the dimer is detected only in the fraction BI (Fig. 22). The dimer fraction (fraction BI) accounted for 4 period of total single chain Fvs. More than 90% of the dimer in the dimer fraction was stably preserved for more than a month at 4°C .

5.10 Construction of vector expressing single chain Fv derived from antibody MABL-2 in *E. coli* cell

[0152] The pscM2 vector was modified by the PCR method to prepare a vector effectively expressing the single chain Fv from the antibody MABL-2 in *E. coli* cells. The resultant DNA fragment was introduced into pSCFVT7 expression vector.

[0153] As a forward primer for PCR, Nde-VHSm02 primer shown in SEQ ID No. 27 was designed to hybridize to a DNA encoding the N-terminal of the H chain V region and to contain a start codon and Ndel restriction enzyme recognition site. As a reverse primer for PCR, VLAS primer shown in SEQ ID No. 28 was designed to hybridize to a DNA encoding the C-terminal of the L chain V region and to contain two stop codons and EcoRI restriction enzyme recognition site. The forward primer, Nde-VHSm02, comprises five point mutations in the part hybridizing to the DNA encoding the N-terminal of the H chain V region for the effective expression in *E. coli*.

[0154] 100 μl of a PCR solution comprising 10 μl of 10 x PCR Buffer #1, 1 mM MgCl₂, 0.2 mM dNTPs, 5 units of KOD DNA polymerase (all from TOYOBO), 1 μM of each primer and 100 ng of a template DNA (pscM2) was heated at 98°C for 15 seconds, at 65°C for 2 seconds and at 74°C for 30 seconds in order. This temperature cycle was repeated 25 times.

[0155] The PCR product was purified using the QIAquick PCR Purification Kit (QIAGEN) and digested by Ndel and EcoRI, and then the resulting DNA fragment was cloned into pSCFVT7 vector, from which pelB signal sequence had been eliminated by the digestion with Ndel and EcoRI. After DNA sequencing, the resulting plasmid comprising a DNA fragment with the desired DNA sequence is designated as "pscM2DEm02" (see Fig. 23). The nucleotide sequence and the amino acid sequence of the single chain Fv derived from the antibody MABL-2 contained in the plasmid pscM2DEm02 are shown in SEQ ID No. 29.

5.11 Expression of single chain Fv derived from antibody MABL-2 in E. coli cells

[0156] E. coli BL21(DE3)pLysS (STRATAGENE) was transformed with pscM2DEm02 vector to obtain a strain of E. coli expressing the single chain Fv derived from antibody MABL-2. The resulting clones were examined for the expression of the desired protein using SDS-PAGE, and a . clone with a high expression level was selected as a strain producing the single chain Fv derived from antibody MABL-2.

5.12 Purification of single chain Fv derived from antibody MABL-2 produced in E.coli

[0157] A single colony of E. coli obtained by the transformation was cultured in 3 ml of LB medium at 28°C for 7 hours and then in 70 ml of LB medium at 28°C overnight. This pre-culture was transplanted to 7 L of LB medium and cultured at 28°C with stirring at 300 rpm using the Jar-fermenter. When an absorbance of the medium reached O.D. =1.5, the bacteria were induced with 1 mM IPTG and then cultured for 3 hours.

[0158] The culture medium was centrifuged (10000 × g, 10 minutes) and the precipitated bacteria were recovered. To the bacteria was added 50 mM Tris-HCl buffer (pH 8.0) containing 5 mM EDTA, 0.1 M NaC and 1% Triton X-100 and the bacteria were disrupted by ultrasonication (out put: 4, duty cycle: 70%, 1 minute × 10 times). The suspension of disrupted bacteria was centrifuged (12000 × g, 10 minutes) to precipitate inclusion body. Isolated inclusion body was mixed with 50 mM Tris-HCl buffer (pH 8.0) containing 5 mM EDTA, 0.1 M NaCl and 4% Triton X-100, treated by ultrasonication (out put: 4, duty cycle: 50%, 30 seconds × 2 times) again and centrifuged (12000 × g, 10 minutes) to isolate the desired protein as precipitate and to remove containment proteins included in the supernatant.

[0159] The inclusion body comprising the desired protein was lysed in 50 mM Tris-HCl buffer (pH 8.0) containing 6 M Urea, 5 mM EDTA and 0.1 M NaCl and applied onto Sephadryl S-3,00 gel filtration column (5 × 90 cm, Amersham Pharmacia) equilibrated with 50 mM Tris-HCl buffer (pH 8.0) containing 4M Urea, 5 mM EDTA, 0.1 M NaCl and 10 mM mercaptoethanol at a flow rate of 5 ml/minutes to remove associated single chain Fvs with high-molecular weight. The obtained fractions were analyzed with SDS-PAGE and the fractions with high purity of the protein were diluted with the buffer used in the gel filtration up to O.D₂₈₀=0.25. Then, the fractions were dialyzed three times against 50 mM Tris-HCl buffer (pH 8.0) containing 5 mM EDTA, 0.1 M NaCl, 0.5 M Arg, 2 mM glutathione in the reduced form and 0.2 mM glutathione in the oxidized form in order for the protein to be refolded. Further, the fraction was dialyzed three times against 20 mM acetate buffer (pH 6.0) containing 0.15 M NaCl to exchange the buffer.

[0160] The dialysate product was applied onto Superdex 200 pg gel filtration column (2.6 × 60 cm, Amersham Pharmacia) equilibrated with 20 mM acetate buffer (pH 6.0) containing 0.15 M NaCl to remove a small amount of high molecular weight protein which was intermolecularly crosslinked by S-S bonds. As shown in Fig. 24, two peaks, major and sub peaks, were eluted after broad peaks which are expectedly attributed to an aggregate with a high molecular weight. The analysis by SDS-PAGE (see Fig. 21) and the elution positions of the two peaks in the gel filtration analysis suggest that the major peak is of the monomer of the single chain Fv and the sub peak is of the non-covalently bound dimer of the single chain Fv. The non-covalently bound dimer accounted for 4 percent of total single chain Fvs.

5.13 Apoptosis-inducing activity in vitro of single chain Fv derived from antibody MABL-2

[0161] An apoptosis-inducing action of the single chain Fv from antibody MABL-2 (MABL2-scFv) produced by the CHO cells and E. coli was examined according to two protocols by Annexin-V staining (Boehringer Mannheim) using the L1210 cells (hIAP/L1210) into which human IAP gene had been introduced.

[0162] In the first protocol sample antibodies at the final concentration of 3 µg/ml were added to 5 × 10⁴ cells of hIAP/L1210 cell line and cultured for 24 hours. Sample antibodies, i.e., the monomer and the dimer of the single chain Fv of MABL-2 from the CHO cells obtained in Example 5.9, the monomer and the dimer of the single chain Fv of MABL-2 from E. coli obtained in Example 5.12, and the mouse IgG antibody as a control were analyzed. After culturing, the Annexin-V staining was carried out and the fluorescence intensity thereof was measured using the FACScan apparatus (BECTON DICKINSON).

[0163] In the second protocol sample antibodies at the final concentration of 3 µg/ml were added to 5 × 10⁴ cells of hIAP/L1210 cell line, cultured for 2 hours and mixed with anti-FLAG antibody (SIGMA) at the final concentration of 15 µg/ml and further cultured for 22 hours. Sample antibodies of the monomer of the single chain Fv of MABL-2 from the CHO cells obtained in Example 5.9 and the mouse IgG antibody as a control were analyzed. After culturing, the Annexin-V staining was carried out and the fluorescence intensity thereof was measured using the FACScan apparatus.

[0164] Results of the analysis by the Annexin-V staining are shown in Figs. 25-31. The results show that the dimers of the single chain Fv polypeptide of MABL-2 produced in the CHO cells and E. coli remarkably induced cell death (Figs. 26, 27) in comparison with the control (Fig. 25), while no apoptosis-inducing action was observed in the monomers of the single chain Fv polypeptide of MABL-2 produced in the CHO cells and E. coli (Figs. 28, 29). When anti-FLAG antibody was used together, the monomer of the single chain Fv polypeptide derived from antibody MABL-2 produced

in the CHO cells induced remarkably cell death (Fig. 31) in comparison with the control (Fig. 30).

5.14 Antitumor effect of the monomer and the dimer of scFv/CHO polypeptide with a model mouse of human myeloma

5 (1) Quantitative measurement of human IgG in mouse serum

[0165] Measurement of human IgG (M protein) produced by human myeloma cell and contained in mouse serum was carried out by the following ELISA. 100 µL of goat anti-human IgG antibody (BIOSOURCE, Lot#7902) diluted to 1 µg/mL with 0.1% bicarbonate buffer (pH 9.6) was added to each well on 96 wells plate (Nunc) and incubated at 4°C overnight so that the antibody was immobilized. After blocking, 100 µL of the stepwisely diluted mouse serum or human IgG (CAPPEL, Lot#00915) as a standard was added to each well and incubated for 2 hours at a room temperature. After washing, 100 µL of alkaline phosphatase-labeled anti-human IgG antibody (BIOSOURCE, Lot#6202) which had been diluted to 5000 times was added, and incubation was carried out for 1 hour at a room temperature. After washing, a substrate solution was added. After incubation, absorbance at 405 nm was measured using the MICROPLATE READER Model 3550 (BioRad). The concentration of human IgG in the mouse serum was calculated based on the calibration curve obtained from the absorbance values of human IgG as the standard.

20 (2) Preparation of antibodies for administration

[0166] The monomer and the dimer of the scFv/CHO polypeptide were respectively diluted to 0.4 mg/mL or 0.25 mg/mL with sterile filtered PBS(-) on the day of administration to prepare samples for the administration.

25 (3) Preparation of a mouse model of human myeloma

[0167] A mouse model of human myeloma was prepared as follows. KPMM2 cells passaged in vivo (JP-Appl. 7-236475) by SCID mouse (Japan Clare) were suspended in RPMI1640 medium (GIBCO-BRL) containing 10% fetal bovine serum (GIBCO-BRL) and adjusted to 3×10^7 cells/mL. 200 µL of the KPMM2 cell suspension (6×10^6 cells/mouse) was transplanted to the SCID mouse (male, 6 week-old) via caudal vein thereof, which had been subcutaneously injected with the asialo GM1 antibody (WAKO JUNYAKU, 1 vial dissolved in 5 mL) a day before the transplantation.

30 (4) Administration of antibodies

[0168] The samples of the antibodies prepared in (2), the monomer (250 µL) and the dimer (400 µL), were administered to the model mice of human myeloma prepared in (3) via caudal vein thereof. The administration was started from three days after the transplantation of KPMM2 cells and was carried out twice a day for three days. As a control, 200 µL of sterile filtered PBS(-) was likewise administered twice a day for three days via caudal vein. Each group consisted of seven mice.

40 (5) Evaluation of antitumor effect of the monomer and the dimer of scFv/CHO polypeptide with the model mouse of human myeloma

[0169] The antitumor effect of the monomer and the dimer of scFv/CHO polypeptide with the model mice of human myeloma was evaluated in terms of the change of human IgG (M protein) concentration in the mouse serum and survival time of the mice. The change of human IgG concentration was determined by measuring it in the mouse serum collected at 24 days after the transplantation of KPMM2 cells by ELISA described in the above (1). The amount of serum human IgG (M protein) in the serum of the PBS(-)-administered group (control) increased to about 8500 µg/mL, whereas the amount of human IgG of the scFv/CHO dimer-administered group was remarkably low, that is, as low as one-tenth or less than that of the control group. Thus, the results show that the dimer of scFv/CHO strongly inhibits the growth of the KPMM2 cells (Fig. 32). As shown in Fig. 33, a remarkable elongation of the survival time was observed in the scFv/CHO dimer-administered group in comparison with the PBS(-)-administered group.

[0170] From the above, it is confirmed that the dimer of scFv/CHO has an antitumor effect for the human myeloma model mice. It is considered that the antitumor effect of the dimer of scFv/CHO, the modified antibody of the invention, results from the apoptosis-inducing action of the modified antibody.

55 5.15 Hemagglutination Test

[0171] Hemagglutination test and determination of hemagglutination were carried out in accordance with "Immuno-Biochemical Investigation", Zoku-Seikagaku Jikken Koza, edited by the Biochemical Society of Japan, published by

Tokyo Kagaku Dojin.

[0172] Blood was taken from a healthy donor using heparin-treated syringes and washed with PBS(-) three times, and then erythrocyte suspension with a final concentration of 2% in PBS(-) was prepared. Test samples were the antibody MABL-2, the monomer and the dimer of the single chain Fv polypeptide produced by the CHO cells, and the monomer and the dimer of the single chain Fv polypeptide produced by *E. coli*, and the control was mouse IgG (ZYMED). For the investigation of the hemagglutination effect, round bottom 96-well plates available from Falcon were used. 50 µL per well of the aforementioned antibody samples and 50 µL of the 2% erythrocyte suspension were added and mixed in the well. After incubation for 2 hours at 37°C, the reaction mixtures were stored at 4°C overnight and the hemagglutination thereof was determined. As a control, 50 µL per well of PBS (-) was used and the hemagglutination test was carried out in the same manner. The mouse IgG and antibody MABL-2 were employed at 0.01, 0.1, 1.0, 10.0 or 100.0 µg/mL of the final concentration of the antibodies. The single chain Fvs were employed at 0.004, 0.04, 0.4, 4.0, 40.0 or 80.0 µg/mL of the final concentration and further at 160.0 µg/mL only in the case of the dimer of the polypeptide produced by *E. coli*. Results are shown in the Table 2. In the case of antibody MABL-2, the hemagglutination was observed at a concentration of more than 0.1 µg/mL, whereas no hemagglutination was observed for both the monomer and the dimer of the single chain Fv.

Table 2

Hemagglutination Test										
	Control	0.01	0.1	1	10	100	µg/mL			
mlgG	Control	-	-	-	-	-				
MABL-2 (intact)	-	-	+	+++	+++	++				
scFv/CHO monomer	Control	0.004	0.04	0.4	4	40	80	µg/mL		
scFv/CHO dimer	-	-	-	-	-	-	-			
scFv/E.coli monomer	Control	0.004	0.04	0.4	4	40	80	160	µg/mL	
scFv/E.coli dimer	-	-	-	-	-	-	-	-		

Example 6 Modified antibody sc(Fv)₂ comprising two H chain V regions and two L chain V regions and antibody MABL-2 scFvs having linkers with different length

6.1 Construction of plasmid expressing antibody MABL-2 sc(Fv)₂

[0173] For the preparation of a plasmid expressing the modified antibody [sc(Fv)₂] which comprises two H chain V regions and two L chain V regions derived from the antibody MABL-2, the aforementioned pCHOM2, which comprises the DNA encoding scFv derived from the MABL-2 described above, was modified by the PCR method as mentioned below and the resulting DNA fragment was introduced into pCHOM2.

[0174] Primers employed for the PCR are EF1 primer (SEQ ID NO: 30) as a sense primer, which is designed to hybridize to a DNA encoding EF1 α , and an antisense primer (SEQ ID NO: 19), which is designed to hybridize to the DNA encoding C-terminal of the L chain V region and to contain a DNA sequence coding for a linker region, and VLLAS primer containing Sall restriction enzyme recognition site (SEQ ID NO 31).

[0175] 100 µl of the PCR solution comprises 10 µl of 10 × PCR Buffer #1, 1 mM MgCl₂, 0.2 mM dNTPs (dATP, dGTP, dCTP and dTTP), 5 units of KOD DNA polymerase (Toyobo, Inc.), 1 µM of each primer and 100 ng of the template DNA (pCHOM2). The PCR solution was heated at 94°C for 30 seconds, at 50°C for 30 seconds and at 74°C for 1 minute in order. This temperature cycle was repeated 30 times.

[0176] The PCR product was purified using the QIAquick PCR Purification Kit (QIAGEN) and digested by Sall. The resultant DNA fragment was cloned into pBluescript KS⁺ vector (Toyobo, Inc.). After DNA sequencing, a plasmid comprising the desired DNA sequence was digested by Sall and the obtained DNA fragment was connected using Rapid DNA Ligation Kit(BOEHRINGER MANNHEIM) to pCHOM2 digested by Sall. After DNA sequencing, a plasmid comprising the desired DNA sequence is designated as "pCHOM2(Fv)₂" (see Fig. 34). The nucleotide sequence and the

amino acid sequence of the antibody MABL-2 sc(Fv)₂ region contained in the plasmid pCHOM2(Fv)₂ are shown in SEQ ID No. 32.

6.2 Preparation of Plasmid expressing antibody MABL-2 scFvs having linkers with various length

- [0177] The scFvs containing linkers with different length and the V regions which are designed in the order of [H chain]-[L chain] (hereinafter "HL") or [L chain]-[H chain] (hereinafter "LH") were prepared using, as a template, cDNAs encoding the H chain and the L chain derived from the MABL-2 as mentioned below.
- [0178] To construct HL type scFv the PCR procedure was carried out using pCHOM2(Fv)₂ as a template. In the PCR step, a pair of CFHL-F1 primer (SEQ ID NO: 33) and CFHL-R2 primer (SEQ ID NO: 34) or a pair of CFHL-F2 primer (SEQ ID NO: 35) and CFHL-R1 primer (SEQ ID NO: 36) and KOD polymerase were employed. The PCR procedure was carried out by repeating 30 times the temperature cycle consisting of 94°C for 30 seconds, 60°C for 30 seconds and 72°C for 1 minute in order to produce a cDNA for the H chain containing a leader sequence at 5'-end or a cDNA for the L chain containing FLAG sequence at 3'-end thereof. The resultant cDNAs for the H chain and the L chain were mixed and PCR was carried out by repeating 5 times the temperature cycle consisting of 94°C for 30 seconds, 60°C for 30 seconds and 72°C for 1 minute in order using the mixture as templates and the KOD polymerase. To the reaction mixture were added CFHL-F1 and CFHL-R1 primers and then the PCR reaction was performed by repeating 30 times of the aforementioned temperature cycle to produce a cDNA for HL-0 type without a linker.
- [0179] To construct LH type scFv, the PCR reaction was carried out using, as a template, pGEM-M2L and pGEM-M2H which contain cDNAs encoding the L chain V region and the H chain V region from the antibody MABL-2, respectively (see JP- Appl. 11-635557). A pair of T7 primer (SEQ ID NO: 37) and CFLH-R2 primer (SEQ ID NO: 38) or a pair of CFLH-F2 primer (SEQ ID NO: 39) and CFLH-R1 (SEQ ID NO: 40) and the KOD polymerase (Toyobo Inc.) were employed. The PCR reaction was performed by repeating 30 times the temperature cycle consisting of 94°C for 30 seconds, 60°C for 30 seconds and 72°C for 1 minute in sequential order to produce a cDNA of an L chain containing a leader sequence at 5'-end or a cDNA of an H chain containing FLAG sequence at 3'-end thereof. The resultant cDNAs of the L chain and the H chain were mixed and PCR was carried out using this mixture as templates and the KOD polymerase by repeating 5 times the temperature cycle consisting of 94°C for 30 seconds, 60°C for 30 seconds and 72°C for 1 minute in order. To the reaction mixture were added T7 and CFLH-R1 primers and the reaction was performed by repeating 30 times of the aforementioned temperature cycle. The reaction product was used as a template and PCR was carried out using a pair of CFLH-F4 primer (SEQ ID NO: 41) and CFLH-R1 primer by repeating 30 times the temperature cycle consisting of 94°C for 30 seconds, 60°C for 30.seconds and 72°C for 1 minute in order to produce a cDNA of LH-0 type without a linker.
- [0180] The resultant cDNAs of LH-0 and HL-0 types were digested by EcoRI and BamHI restriction enzymes (Takara Shuzo) and the digested cDNAs were introduced into an expression plasmid INPEP4 for mammalian cells using Ligation High (Toyobo Inc.), respectively. Competent *E. coli* JM109 (Nippon Gene) was transformed with each plasmid and the desired plasmids were isolated from the transformed *E. coli* using QIAGEN Plasmid Maxi Kit (QUIAGEN). Thus plasmids pCF2LH-0 and pCF2HL-0 were prepared.
- [0181] To construct the expression plasmids of HL type containing linkers with different size, pCF2HL-0, as a template, and CFHL-X3 (SEQ ID NO: 42), CFHL-X4 (SEQ ID NO: 43), CFHL-X5 (SEQ ID NO: 44), CFHL-X6 (SEQ ID NO: 45) or CFHL-X7 (SEQ ID NO: 46), as a sense primer, and BGH-1 (SEQ ID NO: 47) primer, as an antisense primer, which is complementary with the vector sequence were employed. PCR reaction was carried out using the KOD polymerase by repeating 30 times the temperature cycle consisting of 94°C for 30 seconds, 60°C for 30 seconds and 72°C for 1 minute in order and the reaction products were digested by restriction enzymes Xhol and BamHI (Takara Shuzo). The digested fragments were introduced between Xhol and BamHI sites in the pCF2HL-0 using Ligation High (Toyobo Inc.), respectively. Competent *E. coli* JM109 was transformed with each plasmid and the desired plasmids were isolated from the transformed *E. coli* by using Qiagen Plasmid Maxi kit. Thus expression plasmids pCF2HL-3, pCF2HL-4, pCF2HL-5, pCF2HL-6 and pCF2HL-7 were prepared.
- [0182] To construct expression plasmid for the transient expression in COS7 cells the plasmids pCF2HL-0, pCF2HL-3, pCF2HL-4, pCF2HL-5, pCF2HL-6 and pCF2HL-7 were digested by restriction enzymes EcoRI and BamHI (Takara Shuzo) and the resultant fragments of approximately 800 bp were purified with agarose gel electrophoresis. The obtained fragments were introduced between EcoRI and BamHI sites in an expression plasmid pCOS1 for the expression in mammalian cells by using Ligation High (Toyobo Inc.), respectively. Competent *E. coli* DH5 α (Toyobo Inc.) was transformed with each plasmid and the desired plasmids were isolated from the transformed *E. coli* using Qiagen Plasmid Maxi kit. Thus the expression plasmids CF2HL-0/pCOS1, CF2HL-3/pCOS1, CF2HL-4/pCOS1, CF2HL-5/pCOS1, CF2HL-6/pCOS1 and CF2HL-7/pCOS1 were prepared.
- [0183] As a typical example of these plasmids, the construction of the plasmid CF2HL-0/pCOS1 is illustrated in Fig. 35 and the nucleotide sequence and the amino acid sequence of MABL2-scFv <HL-0> contained in the plasmid are shown in SEQ ID No. 48. Nucleotide sequences and amino acid sequences of the linker regions in these plasmids are

also shown in Fig. 36.

[0184] To construct the expression plasmids of LH type containing linkers with different size, pCF2LH-0, as a template, and CFLH-X3 (SEQ ID NO: 49), CFLH-X4 (SEQ ID NO: 50), CFLH-X5 (SEQ ID NO: 51), CFLH-X6 (SEQ ID NO: 52) or CFLH-X7 (SEQ ID NO: 53), as a sense primer, and BGH-1 primer, as an antisense primer, which is complementary with the vector sequence were employed. PCR reaction was carried out using the KOD polymerase by repeating 30 times the temperature cycle consisting of 94°C for 30 seconds, 60°C for 30 seconds and 72°C for 1 minute in order and the reaction products were digested by restriction enzymes Xhol and BamHI. The digested fragments were introduced into the pCF2LH-0 between Xhol and BamHI sites using Ligation High, respectively. Competent *E. coli* DH5 α (Toyobo Inc.) was transformed with each plasmid and the desired plasmids were isolated from the transformed *E. coli* using Qiagen Plasmid Maxi kit. Thus expression plasmids pCF2LH-3, pCF2LH-4, pCF2LH-5, pCF2LH-6 and pCF2LH-7 were prepared.

[0185] To construct expression plasmid for the transient expression in COS7 cells the plasmids pCF2LH-0, pCF2LH-3, pCF2LH-4, pCF2LH-5, pCF2LH-6 and pCF2LH-7 were digested by restriction enzymes EcoRI and BamHI (Takara Shuzo) and the resultant fragments of approximately 800 bp were purified with agarose gel electrophoresis. The obtained fragments were introduced between Xhol and BamHI sites in an expression plasmid pCOS1 for the expression in mammalian cells by using the Ligation High, respectively. Competent *E. coli* DH5 α (Toyobo Inc.) was transformed with each plasmid and the desired plasmids were isolated from the transformed *E. coli* using the Qiagen Plasmid Maxi kit. Consequently, the expression plasmids CF2LH-0/pCOS1, CF2LH-3/pCOS1, CF2LH-4/pCOS1, CF2LH-5/pCOS1, CF2LH-6/pCOS1 and CF2LH-7/pCOS1 were prepared.

[0186] As a typical example of these plasmids, the construction of the plasmid CF2LH-0/pCOS1 is illustrated in Fig. 37 and the nucleotide sequence and the amino acid sequence of MABL2-scFv <LH-0> contained in the plasmid are shown in SEQ ID No. 54. Nucleotide sequences and amino acid sequences of the linker regions in these plasmids are also shown in Fig. 38.

6.3 Expression of scFvs and sc(Fv)₂ in COS7 cells

(1) Preparation of culture supernatant using serum-containing culture medium

[0187] The HL type and LH type of scFvs and sc(Fv)₂ were transiently expressed in COS7 cells (JCRB9127, Japan Health Sciences Foundation). COS7 cells were subcultured in DMEM media (GIBCO BRL) containing 10% fetal bovine serum (HyClone) at 37°C in carbon dioxide atmosphere incubator. The COS7 cells were transfected with CF2HL-0, 3 ~ 7/pCOS1, or CF2LH-0, 3 ~ 7/pCOS1 prepared in Example 6.2 or pCHOM2(Fv)₂ vectors by electroporation using the Gene Pulser apparatus (BioRad). The DNA (10 μ g) and 0.25 ml of 2 \times 10⁷ cells/ml in DMEM culture medium containing 10% FBS and 5 mM BES (SIGMA) were added to a cuvette. After standing for 10 minutes the mixtures were treated with pulse at 0.17kV, 950 μ F of electric capacity. After the restoration for 10 minutes at room temperature, the electroporated cells were transferred into the DMEM culture medium (10%FBS) in 75 cm³ flask. After culturing for 72 hours, the culture supernatant was collected and centrifuged to remove cell fragments. The culture supernatant was subjected to the filtration using 0.22 μ m bottle top filter (FALCON) to obtain the culture supernatant (hereinafter "CM").

(2) Preparation of culture supernatant using serum-free culture medium

[0188] Cells transfected in the same manner as (1) were transferred to the DMEM medium (10% FBS) in 75 cm³ flask and cultured overnight. After the culture, the supernatant was discarded and the cells were washed with PBS and then added to CHO-S-SFM II medium (GIBCO BRL). After culturing for 72 hours, the culture supernatant was collected, centrifuged to remove cell fragments and filtered using 0.22 μ m bottle top filter (FALCON) to obtain CM.

6.4 Detection of scFvs and sc(Fv)₂ in CM of COS7

[0189] The various MABL2-scFVs and sc(Fv)₂ in CM of COS7 prepared in the aforementioned Example 6.3 (2) were detected by Western Blotting method.

[0190] Each CM of COS7 was subjected to SDS-PAGE electrophoresis and transferred to REINFORCED NC membrane (Schleicher & Schuell). The membrane was blocked with 5% skim milk (Morinaga Nyu-gyo) and washed with TBS. Then an anti-FLAG antibody (SIGMA) was added thereto. The membrane was incubated at room temperature and washed. A peroxidase labeled mouse IgG antibody (Jackson Immuno Research) was added. After incubating and washing at room temperature, the substrate solution (Kirkegaard Perry Laboratories) was added to develop color (Fig. 39).

6.5 Flow cytometry

[0191] Flow cytometry was performed using the culture supernatants of COS7 cells prepared in Example 6.3 (1) to measure the binding of the MABL2-scFVs and sc(Fv)₂ to human Integrin Associated Protein (IAP) antigen. The culture supernatants to be tested or a culture supernatant of COS7 cells as a control was added to 2 × 10⁵ cells of the mouse leukemia cell line L1210 expressing human IAP. After incubating on ice and washing, 10 µg/mL of the mouse anti-FLAG antibody (SIGMA) was added and then the cells were incubated and washed. Then, the FITC labeled anti-mouse IgG antibody (BECTON DICKINSON) was added thereto and the cells were incubated and washed again. The fluorescence intensity was measured using the FACScan apparatus (BECTON DICKINSON). The results of the flow cytometry show that the MABL2-scFVs having linkers with different length and the sc(Fv)₂ in the culture supernatants of COS7 have high affinity to human IAP (see Figs. 40a and 40b).

6.6 Apoptosis-inducing Effect in vitro

[0192] An apoptosis-inducing action of the culture supernatants of COS7 prepared in Example 6.3 (1) was examined by Annexin-V staining (Boehringer Mannheim) using the L1210 cells transfected with human IAP gene (hIAP/L1210). [0193] To 5 × 10⁴ cells of the hIAP/L1210 cells were added the culture supernatants of COS7 cells transfected with each vectors or a culture supernatant of COS7 cells as a control at 10% of the final concentration and the mixtures were cultured for 24 hours. Then, the Annexin-V/PI staining was performed and the fluorescence intensity was measured using the FACScan apparatus (BECTON DICKINSON). The results revealed that scFvs <HL3, 4, 6, 7, LH3, 4, 6, 7> and sc(Fv)₂ in CM of COS7 induced remarkable cell death of hIAP/L1210 cells. These results are shown in Fig. 41.

6.7 Construction of vectors for the expression of scFvs and sc(Fv)₂ in CHO cells

[0194] To isolate and purify MABL2-scFVs and sc(Fv)₂ from culture supernatant, the expression vectors for expressing in CHO cells were constructed as below.
[0195] The EcoRI-BamHI fragments of pCF2HL-0, 3 ~ 7, and pCF2LH-0, 3 ~ 7 prepared in Example 6.2 were introduced between EcoRI and BamHI sites in an expression vector pCHO1 for CHO cells using the Ligation High. Competent *E. coli* DH5α was transformed with them. The plasmids were isolated from the transformed *E. coli* using QIAGEN Plasmid Midi kit (QIAGEN) to prepare expression plasmids pCHOM2HL-0, 3 ~ 7, and pCHOM2LH-0, 3 ~ 7.

6.8 Production of CHO cells expressing MABL2-scFvs <HL-0, 3 ~ 7>, MABL2-scFvs <LH-0, 3 ~ 7> and sc(Fv)₂ and preparation of the culture supernatants thereof

[0196] CHO cells were transformed with each of the expression plasmids pCHOM2HL-0, 3 ~ 7, and pCHOM2LH-0, 3 ~ 7, constructed in Example 6.7 and pCHOM2(Fv)₂ vector to prepare the CHO cells constantly expressing each modified antibody. As a typical example thereof, the production of the CHO cells constantly expressing MABL2-scFv <HL-5> or sc(Fv)₂ is illustrated as follows.
[0197] The expression plasmids pCHOM2HL-5 and pCHON2(Fv)₂ were linearized by digesting with a restriction enzyme Pvul and subjected to transfection to CHO cells by electroporation using Gene Pulser apparatus (BioRad). The DNA (10 µg) and 0.75 ml of PBS with 1 × 10⁷ cells/ml were added to a cuvette and treated with pulse at 1.5 kV, 25 µF of electric capacity. After the restoration for 10 minutes at room temperature, the electroporated cells were transferred into nucleic acid-containing α-MEM culture medium (GIBCO BRL) containing 10% fetal bovine serum and cultured. After culturing overnight, the supernatant was discarded. The cells were washed with PBS and added to nucleic acid-free α-MEM culture medium (GIBCO BRL) containing 10% fetal bovine serum. After culturing for two weeks, the cells were cultured in a medium containing 10 nM (final concentration) methotrexate (SIGMA), then 50 nM and 100 nM methotrexate. The resultant cells were cultured in serum-free CHO-S-SFM II medium (GIBCO BRL) in a roller bottle. The culture supernatant was collected, centrifuged to remove cell fragments and filtered using a filter with 0.22 µm of pore size to obtain CM, respectively.
[0198] According to the above, CHO cells which constantly express MABL2-scFvs <HL-0, -3, -4, -6, -7> and <LH-0, -3, -4, -5, -6, -7> and CMs thereof were obtained.

6.9 Purification of dimer of MABL2-scFv <HL-5> and sc(Fv)₂

[0199] The MABL2-scFv <HL-5> and the sc(Fv)₂ were purified from CMs prepared in Example 6.8 by two types of purification method as below.

<Purification Method 1>

[0200] HL-5 and sc(Fv)₂ were purified by the anti-FLAG antibody affinity column chromatography utilizing the FLAG sequence located at C-terminal of the polypeptides and by gel filtration. One liter of CM as obtained in 6.8 was applied onto a column (7.9ml) prepared with anti-FLAG M2 Affinity gel (SIGMA) equilibrated with 50 mM Tris-HCl buffer (TBS, pH 7.5) containing 150 mM NaCl. After washing the column with TBS, the scFv was eluted by 0.1 M glycine-HCl buffer, pH 3.5. The resultant fractions were analyzed by SDS-PAGE and the elution of the scFv was confirmed. The scFv fraction was mixed with Tween 20 up to 0.01% of the final concentration and concentrated using Centricon-10 (MILIPOR). The concentrate was applied onto TSKgel G3000SWG column (7.5 × 600 mm) equilibrated with 20 mM acetate buffer (pH 6.0) containing 150 mM NaCl and 0.01% Tween 20. At 0.4 mL/minute of the flow rate, the scFv was detected by the absorption at 280 nm. The HL-5 was eluted as the major fraction in the position of the dimer and the sc(Fv)₂ was eluted in the position of the monomer.

<Purification Method 2>

[0201] HL-5 and sc(Fv)₂ were purified using three steps comprising ion exchange chromatography, hydroxyapatite and gel filtration. In the ion exchange chromatography, Q sepharose fast flow column (Pharmacia) was employed for HL-5 and SP-sepharose fast flow column was employed for sc(Fv)₂. In and after the second step, HL-5 and sc(Fv)₂ were processed by the same procedure.

First step for HL-5

[0202] CM of HL-5 was diluted to two times with 20 mM Tris-HCl buffer (pH 9.0) containing 0.02% Tween 20 and then the pH was adjusted to 9.0 with 1 M Tris. The solution was applied onto Q Sepharose fast flow column equilibrated with 20 mM Tris-HCl buffer (pH 8.5) containing 0.02% Tween 20. A polypeptide adsorbed to the column was eluted by a linear gradient of NaCl in the same buffer, from 0.1 to 0.55 M. Monitoring the eluted fractions by SDS-PAGE, the fractions containing HL-5 were collected and subjected to hydroxyapatite of the second step.

First step for sc(Fv)₂

[0203] CM of the sc(Fv)₂ was diluted to two times with 20mM acetate buffer (pH 5.5) containing 0.02% Tween 20 and its pH was adjusted to 5.5 with 1 M acetic acid. The solution was applied onto a SP-Sepharose fast flow column equilibrated with 20 mM acetate buffer (pH 5.5) containing 0.02% Tween 20. A polypeptide adsorbed to the column was eluted by a linear gradient of NaCl in the buffer, from 0 to 0.5 M. Monitoring the eluted fractions by SDS-PAGE, the fractions containing the sc(Fv)₂ were collected and subjected to hydroxyapatite of the second step.

Second step: Hydroxyapatite chromatography of HL-5 and sc(Fv)₂

[0204] The fractions of HL-5 and sc(Fv)₂ obtained in the first step were separately applied onto the hydroxyapatite column (Type I, BIORAD) equilibrated with 10 mM phosphate buffer containing 0.02% Tween 20, pH 7.0. After washing the column with the same buffer, polypeptides adsorbed to the column were eluted by a linear gradient of the phosphate buffer up to 0.5 M. Monitoring the eluted fractions by SDS-PAGE, the fractions containing the desired polypeptides were collected.

Third step: Gel filtration of HL-5 and sc(Fv)₂

[0205] Each fraction obtained at the second step was separately concentrated with CentriPrep-10 (MILIPORE) and applied onto a Superdex 200 column (2.6 × 60 cm, Pharmacia) equilibrated with 20 mM acetate buffer (pH 6.0) containing 0.02% Tween 20 and 0.15 M NaCl. HL-5 was eluted in the position of the dimer, and sc(Fv)HL-5 and sc(Fv)₂ were eluted in the position of the monomer as a major peak respectively.

[0206] Since the monomer of HL-5 was hardly detected by both purification methods, it is proved that the dimers of single chain Fvs are formed in high yields when the linker for the single chain Fv contains around 5 amino acids. Furthermore, the dimer of HL-5 and the sc(Fv)₂ were stably preserved for a month at 4°C after the purification.

6.10 Evaluation of the binding activity of purified dimer of scFv <HL-5> and sc(Fv)₂ against antigen

[0207] Flow cytometry was performed using the purified dimer of MABL2-scFv <HL-5> and the purified sc(Fv)₂ in order to evaluate the binding to human Integrin Associated Protein (IAP). antigen. 10µg/ml of the purified dimer of

MABL2-scFv <HL-5>, the purified sc(Fv)₂, the antibody MABL-2 as a positive control or a mouse IgG (Zymed) as a negative control was added to 2×10^5 cells of the mouse leukemia cell line L1210 expressing human IAP (hIAP/L1210) or the cell line L1210 transformed with pCOS1 (pCOS1/L1210) as a control. After incubating on ice and washing, 10 μ g/mL of the mouse anti-FLAG antibody (SIGMA) was added and then the cells were incubated and washed. FITC labeled anti-mouse IgG antibody (BECTON DICKINSON) was added thereto and the cells were incubated and washed again. Then the fluorescence intensity was measured using the FACScan apparatus (BECTON DICKINSON).

[0208] Since the purified dimer of MABL2-scFv <HL-5> and the purified sc(Fv)₂ were specifically bound to hIAP/L1210 cells, it is confirmed that the dimer of scFv <HL-5> and the sc(Fv)₂ have high affinity to human IAP (see Fig. 42).

10 6.11 Apoptosis-inducing activity in vitro of purified dimer of scFv <HL-5> and sc(Fv)₂

[0209] An apoptosis-inducing action of the purified dimer of MABL2-scFv <HL-5> and the purified sc(Fv)₂ were examined by Annexin-V staining (Boehringer Mannheim) using the L1210 cells (hIAP/L1210) in which human IAP gene had been introduced and cells of human leukemic cell line CCRF-CEM.

15 [0210] Different concentrations of the purified dimer of MABL2-scFv <HL-5>, the purified MABL2-sc(Fv)₂, the antibody MABL-2 as a positive control or a mouse IgG as a negative control were added to 5×10^4 cells of hIAP/L1210 cell line or 1×10^5 cells of CCRF-CEM cell line. After culturing for 24 hours, the Annexin-V staining was carried out and the fluorescence intensity thereof was measured using the FACScan apparatus (BECTON DICKINSON). As a result the dimer of MABL2-scFv <HL-5> and the MABL2-sc(Fv)₂ remarkably induced cell death of hIAP/L1210 and CCRF-CEM in concentration-dependent manner (see Fig. 43). As a result it was shown that the dimer of MABL2-scFv <HL-5> and MABL2-sc(Fv)₂, had improved efficacy of inducing apoptosis compared with original antibody MABL-2.

20 6.12 Hemagglutination Test of the purified dimer of scFv <HL-5> and the sc(Fv)₂

25 [0211] Hemagglutination test was carried out using different concentrations of the purified dimer of scFv <HL-5> and the purified sc(Fv)₂ in accordance with Example 5.15.

[0212] The hemagglutination was observed with the antibody MABL-2 as a positive control, whereas no hemagglutination was observed with both the single chain antibody MABL2-sc(Fv)₂ and the MABL2-scFv <HL-5>. Further, there was no substantial difference in the hemagglutination between two buffers employed with the antibody MABL-2. These results are shown in Table 3.

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55

Hemagglutination Test

TABLE 3

Diluent : PBS

(μg/ml)

		Diluent : PBS																
		Diluent : Acetate Buffer																
		(μg/ml)																
cont	28.9	14.45	7.225	3.6125	1.8063	0.9031	0.4516	0.2258	0.1129	0.0564	0.0282	0.0141	0.0071	0.0035	0.0018	—	—	
MABL2-sc(Fv) ₂	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
MABL2-sc(Fv) ₂ <HL5>	cont	28.0	14.0	7.0	3.5	1.75	0.875	0.4375	0.2188	0.1094	0.0547	0.0273	0.0137	0.0068	0.0034	0.0017	—	—
MABL2 (intact)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
mlgG	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

6.13 Antitumor effect of the purified dimer of scFv <HL-5> and the sc(Fv)₂ for a model mouse of human myeloma

[0213] The antitumor effects were tested for the dimer of scFv <HL-5> and the sc(Fv)₂ prepared and purified in Examples 6.8 and 6.9. The test was performed by using the mouse model for human myeloma produced in Example 5.1 and determining the amount of M protein produced by human myeloma cells in the mouse serum using ELISA and examining survival time of the mice. Then, the antitumor effects of the dimer of scFv <HL-5> and the sc(Fv)₂ were evaluated in terms of the change of the amount of M protein in the mouse serum and the survival time of the mice.

[0214] In the test, the HL-5 and the sc(Fv)₂ were employed as a solution at 0.01, 0.1 or 1 mg/mL in vehicle consisting of 150 mM NaCl, 0.02% Tween and 20 mM acetate buffer, pH 6.0 and administered to the mice at 0.1, 1 or 10 mg/kg of dosage. Control group of mice were administered only with the vehicle.

[0215] The mouse serum was gathered 26 days after the transplantation of the human myeloma cells and the amount of M protein in the serum was measured using ELISA according to Example 5.14. As a result, the amount of M protein in the serum of both mice groups administered with HL-5, the dimer and the sc(Fv)₂ decreased in dose-dependent manner (see Fig. 44). Furthermore, a significant elongation of the survival time was observed in both groups administered with the HL-5 (Fig. 45) and with the sc(Fv)₂ (Fig. 46) in comparison with the control group administered with the vehicle. These results show that the HL-5 and the sc(Fv)₂ of the invention have excellent antitumor effect *in vivo*.

Example 7

20 Single chain Fv comprising H chain V region and L chain V region of human antibody 12B5 against human MPL

[0216] A DNA encoding V regions of human monoclonal antibody 12B5 against human MPL was constructed as follows:

25 7.1 Construction of a gene encoding H chain V region of 12B5

[0217] The gene encoding H chain V region of human antibody 12B5 binding to human MPL was designed by connecting the nucleotide sequence of the gene thereof (SEQ ID NO: 55) at the 5'-end to the leader sequence (SEQ ID NO: 56) originated from human antibody gene (Eur. J. Immunol. 1996; 26: 63-69). The designed nucleotide sequence was divided into four oligonucleotides having overlapping sequences of 15 bp each (12B5VH-1, 12B5VH-2, 12B5VH-3, 12B5VH-4). 12B5VH-1 (SEQ ID NO: 57) and 12B5VH-3 (SEQ ID NO: 59) were synthesized in the sense direction, and 12B5VH-2 (SEQ ID NO: 58) and 12B5VH-4 (SEQ ID NO: 60) in the antisense direction, respectively. After assembling each synthesized oligonucleotide by respective complementarity, the outside primers (12B5VH-S and 12B5VH-A) were added to amplify the full length of the gene. 12B5VH-S (SEQ ID NO: 61) was designed to hybridize to 5'-end of the leader sequence by the forward primer and to have Hind III restriction enzyme recognition site and Kozak sequence, and 12B5VH-A (SEQ ID NO: 62) was designed to hybridize to the nucleotide sequence encoding C-terminal of H chain V region by the reverse primer and to have a splice donor sequence and BamHI restriction enzyme recognition site, respectively.

[0218] 100µl of the PCR solution containing 10µl of 10 x PCR Gold Buffer II, 1.5mM MgCl₂, 0.08mM dNTPs (dATP, dGTP, dCTP, dTTP), 5 units of DNA-polymerase AmpliTaq Gold (all by PERKIN ELMER) and each 2.5 p mole of each synthesized oligonucleotide (12B5VH-1 to -4) was heated at 94°C of the initial temperature for 9 minutes, at 94°C for 2 minutes, at 55°C for 2 minutes and 72°C for 2 minutes. After repeating the cycle two times each 100 pmole of external primer 12B5VH-S and 12B5VH-A was added. The mixture was subjected to the cycle consisting of at 94°C for 30 seconds, at 55°C for 30 seconds and 72°C for 1 minute 35 times and, heated at 72°C for further 5 minutes.

[0219] The PCR product was purified by 1.5% low-melting-temperature agarose gel (Sigma), digested by restriction enzymes BamHI and Hind III, and cloned into expression vector HEF-gy1 for human H chain. After determining the DNA sequence the plasmid containing the correct DNA sequence was named HEF-12B5H-gy1.

[0220] The HEF-12B5H-gy1 was digested by restriction enzymes EcoRI and BamHI to produce the gene encoding 12B5VH which was then cloned into an expression vector pCOS-Fd for human Fab H chain to produce pFd-12B5H. The expression vector for human Fab H chain was constructed by amplifying the DNA (SEQ ID NO: 63) containing the intron region existing between the genes encoding human antibody H chain V region and the constant region, and the gene encoding a part of the constant region of human H chain by PCR, and inserting the PCR product into animal cell expression vector pCOS1. The human H chain constant region was amplified for the gene under the same conditions mentioned above using as the template HEF-gy1, as the forward primer G1CH1-S (SEQ ID NO: 64) which was designed to hybridize to 5'-end sequence of intron 1 and to have restriction enzyme recognition sites EcoRI and BamHI and as the reverse primer G1CH1-A (SEQ ID NO: 65) which was designed to hybridize to 3'-end DNA of human H chain constant region CH1 domain and to have a sequence encoding a part of hinge region, two stop codons and restriction enzyme recognition site BgI II.

[0221] The nucleotide sequence and amino acid sequence of the reconstructed 12B5H chain variable region which were included in plasmids HEF-12B5H-gy1 and pFd-12B5H are shown in SEQ ID NO: 66.

7.2 Construction of the gene encoding 12B5 L chain V region

[0222] The gene encoding L chain V region of human antibody 12B5 binding to human MPL was designed by connecting the nucleotide sequence of gene (SEQ ID NO: 67) at the 5'-end to the leader sequence (SEQ ID NO: 68) originated from human antibody gene 3D6 (Nuc. Acid Res. 1990; 18; 4927). In the same way as mentioned above the designed nucleotide sequence was divided into four oligonucleotides having overlapping sequences of 15 bp each (12B5VL-1, 12B5VL-2, 12B5VL-3, 12B5VL-4) and synthesized respectively. 12B5VL-1 (SEQ ID NO: 69) and 12B5VL-3 (SEQ ID NO: 71) had sense sequences, and 12B5VL-2 (SEQ ID NO: 70) and 12B5VL-4 (SEQ ID NO: 72) had antisense sequences, respectively. Each of the synthesized oligonucleotides was assembled by respective complementarity and mixed with the external primer (12B5VL-S and 12B5VL-A) to amplify the full length of the gene. 12B5VL-S (SEQ ID NO: 73) was designed to hybridize to 5'-end of the leader sequence by the forward primer and to have Hind III restriction enzyme recognition site and Kozak sequence. 12B5VL-A (SEQ ID NO: 74) was designed to hybridize to the nucleotide sequence encoding C-terminal of L chain V region by the reverse primer and to have a splice donor sequence and BamHI restriction enzyme recognition site.

[0223] Performing the PCR as mentioned above, the PCR product was purified by 1.5% low-melting-temperature agarose gel (Sigma), digested by restriction enzymes BamHI and Hind III, and cloned into an expression vector HEF-g κ for human L chain. After determining the DNA sequence the plasmid containing the correct DNA sequence was named HEF-12B5L-g κ . The nucleotide sequence and amino acid sequence of the reconstructed 12B5 L chain V region which were included in plasmid HEF-12B5L-g κ are shown in SEQ ID NO:75.

7.3 Production of reconstructed 12B5 single chain Fv (scFv)

[0224] The reconstructed 12B5 antibody single chain Fv was designed to be in the order of 12B5VH-linker-12B5VL and to have FLAG sequence (SEQ ID NO: 76) at C-terminal to facilitate the detection and purification. The reconstructed 12B5 single chain Fv (sc12B5) was constructed using a linker sequence consisting of 15 amino acids represented by (Gly₄Ser)₃.

(1) Production of the reconstructed 12B5 single chain Fv using the linker sequence consisting of 15 amino acids

[0225] The gene encoding the reconstructed 12B5 antibody single chain Fv, which contained the linker sequence consisting of 15 amino acids, was constructed by connecting 12B5 H chain V region, linker region and 12B5 L chain V region which was amplified by PCR respectively. This method is schematically shown in Fig. 47. Six PCR primers (A-F) were used for production of the reconstructed 12B5 single chain Fv. Primers A, C, and E had sense sequences, and primers B, D, and F had antisense sequences.

[0226] The forward primer 12B5-S (Primer A, SEQ ID NO: 77) for H chain V region was designed to hybridize to 5'-end of H chain leader sequence and to have EcoRI restriction enzyme recognition site. The reverse primer HuVHJ3 (Primer B, SEQ ID NO: 78) for H chain V region was designed to hybridize to DNA encoding C-terminal of H chain V region.

[0227] The forward primer RHuJH3 (Primer C, SEQ ID NO: 79) for the linker was designed to hybridize to DNA encoding the N-terminal of the linker and to overlap DNA encoding the C-terminal of H chain V region. The reverse primer RHuVK1 (Primer D, SEQ ID NO: 80) for the linker was designed to hybridize to DNA encoding the C-terminal of the linker and overlap DNA encoding the N-terminal of L chain V region.

[0228] The forward primer HuVK1.2 (Primer E, SEQ ID NO: 81) for L chain V region was designed to hybridize to DNA encoding the N-terminal of L chain V region. The reverse primer 12B5F-A for L chain V region (Primer F, SEQ ID NO: 82) was designed to hybridize to DNA encoding C-terminal of L chain V region and to have the sequence encoding FLAG peptide (Hopp, T. P. et al., Bio/Technology, 6, 1204-1210, 1988), two transcription stop codons and NotI restriction enzyme recognition site.

[0229] In the first PCR step, three reactions A-B, C-D, and E-F were performed, and the three PCR products obtained from the first step PCR were assembled by respective complementarity. After adding primers A and F the full length DNA encoding the reconstructed 12B5 single chain Fv having the linker consisting of 15 amino acids was amplified (the second PCR). In the first step PCR, the plasmid HEF-12B5H-gy1 (see Example 7. 1) encoding the reconstructed 12B5 H chain V region, pSCFVT7-hM21 (humanized ONS-M21 antibody) (Ohtomo et al., Anticancer Res. 18 (1998), 4311-4316) containing DNA (SEQ ID NO: 83) encoding the linker region consisting of Gly Gly Gly Gly Ser Gly Gly Gly Gly Ser Gly Gly Gly Ser (Huston et al., Proc. Natl. Acad. Sci. USA, 85, 5879-5883, 1988) and the plasmid HEF-12B5L-g κ (see Example 7. 2) encoding the reconstructed 12B5 L chain V region were used as templates, respectively.

[0230] 50µl of PCR solution for the first step contained 5µl of 10 x PCR Gold Buffer II, 1.5mM MgCl₂, 0.08mM dNTPs, 5 units of DNA polymerase AmpliTaq Gold (all by PERKIN ELMER), each 100 pmole of each primer and 100ng of each template DNA. The PCR solution was heated at 94°C of the initial temperature for 9 minutes, at 94 for 30 seconds, 55°C for 30 seconds and 72°C for 1 minute. After repeating the cycle 35 times the reaction mixture was further heated 5 72°C for 5 minutes.

[0231] The PCR products A-B, C-D, and E-F were assembled by the second PCR. PCR mixture solution for the second step of 98µl containing as the template 1µl of the first PCR product A-B, 0.5µl of PCR product C-D and 1µl of PCR product E-F, 10µl of 10 x PCR Gold Buffer II, 1.5mM MgCl₂, 0.08mM dNTPs, 5 units of DNA polymerase AmpliTaq Gold (all by PERKIN ELMER) was heated at 94°C of the initial temperature for 9 minutes, at 94°C for 2 minutes, at 10 65°C for 2 minutes and 72°C for 2 minutes. After repeating the cycle two times, each 100 pmole of each of primers A and F were added. After repeating the cycle consisting of at 94°C for 30 seconds, 55°C for 30 seconds and 72°C for 1 minute 35 times, the reaction mixture was heated at 72°C for 5 minutes.

[0232] The DNA fragments produced by the second PCR were purified using 1.5% low-melting-temperature agarose gel, digested by EcoRI and NotI, and cloned into pCHO1 vector and pCOS1 vector (Japanese Patent Application No. 15 8-255196). The expression vector pCHO1 was a vector constructed by deleting the antibody gene from DHFR-ΔE-rvH-PM1-f (see WO92/19759) by EcoRI and SmaI digestion, and connecting to EcoRI-NotI-BamHI Adaptor (TAKARA SHUZO). After determining the DNA sequence the plasmids containing the DNA fragment encoding the correct amino acid sequence of reconstructed 12B5 single chain Fv were named pCHO-sc12B5 and pCOS-sc12B5. The nucleotide sequence and amino acid sequence of the reconstructed 12B5 single chain Fv included in the plasmids pCHO-sc12B5 20 and pCOS-sc12B5 are shown in SEQ ID NO: 84.

7.4 Expression of antibody 12B5 (IgG, Fab) and single chain Fv polypeptide by animal cell

[0233] Antibody 12B5 (IgG, Fab) and single chain Fv derived from antibody 12B5 were expressed by using COS-7 25 cells or CHO cells.

[0234] The transient expression using COS-7 cells was performed as follows. The transfection was performed by electroporation method using Gene Pulser equipment (BioRad). For the expression of antibody 12B5 (IgG) each 10µg of the above-mentioned expression vector HEF-12B5H-gy1 and HEF-12 B5L-gk were added, for the expression of 30 12B5Fab fragment each 10µg of pFd-12B5H and HEF-12B5L-gk were added and for the expression of single chain Fv 10µg of pCOS-sc12B5 was added to COS-7 cells (1×10^7 cells/ml) suspended in 0.8ml of PBS. The mixture kept in a cuvette was treated by pulse at the capacity of 1.5kV, 25µFD. After recovering for 10 minutes in a room temperature the electroporated cells were added to DMEM culture medium (GIBCO BRL) containing 10% bovine fetal serum cultivated. After cultivating overnight the cells were washed once by PBS, added to serum-free medium CHO-S-SFM II 35 and cultivated for 2 days. The culture medium was centrifuged to remove cell debris and filtered with 0.22pm filter to prepare the culture supernatant.

[0235] To establish a stable expression CHO cell line for the single chain Fv (polypeptide) derived from antibody 12B5, the expression vector pCHO-sc12B5 was introduced into CHO cells as follows.

[0236] The expression vector was introduced into CHO cells by electroporation method using Gene Pulser equipment (BioRad). Linearized DNA (100µg) obtained by digestion with restriction enzyme Pvul and CHO cells (1×10^7 cells /ml) 40 suspended in 0.8 ml of PBS were mixed in a cuvette, left stationary on ice for 10 minutes and treated with pulse at the capacity of 1.5kV, 25µFD. After recovering for 10 minutes at a room temperature the electroporated cells were added to CHO-S-SFM II (GIBCO BRL) containing 10% bovine fetal serum and cultivated. After cultivating for 2 days the cultivation was continued in CHO-S-SFM II (GIBCO BRL) containing 5nM methotrexate (SIGMA) and 10% bovine fetal serum. From thus obtained clones a clone with high expression rate was selected as the production cell line for 12B5 45 single chain Fv. After cultivating in serum-free medium CHO-S-SFM II (GIBCO BRL) containing 5nM methotrexate (SIGMA), the culture supernatant was obtained by centrifugal separation of cell debris.

7.5 Purification of single chain Fv derived from 12B5 produced by CHO cells

[0237] The culture supernatant of CHO cell line expressing 12B5 single chain Fv obtained in 7.4 was purified by 50 anti-FLAG antibody column and gel filtration column.

(1) Anti-FLAG antibody column

[0238] The culture supernatant was added to anti-FLAG M2 affinity gel (SIGMA) equilibrated by PBS. After washing the column by the same buffer the proteins adsorbed to the column were eluted by 0.1M glycine-HCl buffer (pH 3.5). The eluted fractions were immediately neutralized by adding 1M Tris-HCl buffer (pH 8.0). The eluted fractions were 55 analyzed by SDS-PAGE and the fraction which was confirmed to contain the single chain Fv was concentrated using

Centricon-10 (MILLIPORE).

(2) Gel filtration

- 5 [0239] The concentrated solution obtained in (1) was added to Superdex200 column (10x300mm, AMERSHAM PHARMACIA) equilibrated by PBS containing 0.01% Tween20. The product sc12B5 was eluted in two peaks (A, B) (see Fig. 48). The fractions A and B were analyzed using the 14%-SDS-polyacrylamide gel. The sample was processed by electrophoresis in the presence and absence of a reducing agent according to Laemmli method, and stained by Coomassie Brilliant Blue after the electrophoresis. As shown in Fig. 49 the fractions A and B, regardless of the presence of the reducing agent or its absence, produced a single band having an apparent molecular weight of about 31 kD. When the fractions A and B were analyzed by gel filtration using Superdex200 PC 3.2/30 (3.2x300mm, AMERSHAM PHARMACIA), the fraction A produced an eluted product at an apparent molecular weight of about 44 kD and the fraction B produced at 22kD (see Fig. 50a and b). The results show that the fraction A is the non-covalent bond dimer of sc12B5 single chain Fv, and B is the monomer.

15 7.6 Measurement of TPO-like agonist activity of various single chain Fvs

- 20 [0240] The TPO-like activity of anti-MPL single chain antibody was evaluated by measuring the proliferation activity to Ba/F3 cells (BaF/ml) expressing human TPO receptor (MPL). After washing BaF/Mpl cells two times by RPMI1640 culture medium (GIBCO) containing 10% bovine fetal serum (GIBCO), the cells were suspended in the culture medium at cell density of 5×10^5 cells/ml. The anti-MPL single chain antibody and human TPO (R&D Systems) was diluted with the culture medium, respectively. 50 μ l of the cell suspension and 50 μ l of the diluted antibody or human TPO were added in 96-well microplate (flat bottom) (Falcon), and cultivated in CO₂ incubator (CO₂ concentration: 5%) for 24 hours. After the incubation 10 μ l of WST-8 reagent (reagent for measuring the number of raw cells SF: Nacalai Tesque) was added and the absorbance was immediately measured at measurement wavelength of 450nm and at reference wavelength of 620nm using fluorescence absorbency photometer SPECTRA Fluor (TECAN). After incubating in CO₂ incubator (CO₂ concentration: 5%) for 2 hours, the absorbance at 450nm of measurement wavelength and 620nm of reference wavelength was again measured using SPECTRA Fluor. Since WST-8 reagent developed the color reaction depending upon the number of live cells at wavelength of 450nm, the proliferation activity of BaF/Mpl based on the change of absorbance in 2 hours was evaluated by ED 50 calculated as follows. In the proliferation reaction curve wherein the absorbance was plotted on the ordinate against the antibody concentration on the abscissa, the absorbance at the plateau was set 100% reaction rate. Obtaining an approximation formula by straight line approximation method based on the plotted values close to 50% reaction rate, the antibody concentration of 50% reaction rate was calculated and adopted as ED 50.
- 25 The results of the agonist activity to MPL measured by using culture supernatants of COS-7 cells expressing various 12B5 antibody molecules showed as illustrated in Fig. 51 that 12B5IgG having bivalent antigen-binding site increased the absorbance in concentration-dependent manner and had TPO-like agonist activity (ED50; 29nM), while the agonist activity of 12B5Fab having monovalent antigen-binding site was very weak (ED50; 34,724nM). On the contrary the single chain Fv (sc12B5) having monovalent antigen-binding site like Fab showed strong agonist activity at a level that ED50 was 75nM. However it has been known that variable regions of H chain and L chain of the single chain Fv are associated through non-covalent bond and, therefore, each variable region is dissociated in a solution and can be associated with variable region of other molecule to form multimers like dimers. When the molecular weight of sc12B5 purified by gel filtration was measured, it was confirmed that there were molecules recognized to be monomer and dimer (see Fig. 48). Then monomer sc12B5 and dimer sc12B5 were isolated (see Fig. 50) and measured for the agonist activity to MPL. As shown in Figs. 51 and 52, ED50 of sc12B5 monomer was 4438.7nM, which confirmed that the agonist activity was reduced compared with the result using culture supernatant of COS-7 cells. On the contrary single chain Fv (sc12B5 dimer) having bivalent antigen-binding site showed about 400-fold stronger agonist activity (ED50; 10.1nM) compared with monovalent sc12B5. Furthermore, the bivalent single chain Fv showed the agonist activity equivalent to or higher than the agonist activity of human TPO and 12B5IgG.

30 Example 8

Construction of a gene encoding the variable region of human antibody 12E10 against human MPL

- 35 [0241] A DNA encoding variable region of human monoclonal antibody 12E10 against human MPL was constructed as follows:

8.1 Construction of a gene encoding 12E10 H chain V region

[0242] The nucleotide sequence SEQ ID NO:86 was designed as a gene encoding H chain V region of human antibody 12E10 binding to human MPL on the basis of the amino acid sequence described in WO99/1049 (SEQ ID NO: 85). The full length of nucleotide sequence was designed by connecting to its 5'-end the leader sequence (SEQ ID NO:87) derived from human antibody gene (GenBank accession No. AF062252). The designed nucleotide sequence was divided into four oligonucleotides having overlapping sequences of 15 bp each (12E10VH1, 12E10VH2, 12E10VH3, 12E10VH4) . 12E10VH1 (SEQ ID NO: 88) and 12E10VH3 (SEQ ID NO: 90) were synthesized in the sense direction, and 12E10VH2 (SEQ ID NO: 89) and 12E10VH4 (SEQ ID NO: 91) in the antisense direction, respectively.

5 After assembling each synthesized oligonucleotide by respective complementarity, the external primers (12E10VHS and 12E10VHA) were added to amplify the full length of the gene. 12E10VHS (SEQ ID NO: 92) was designed to hybridize to 5'-end of the leader sequence by the forward primer and to have Hind III restriction enzyme recognition site and Kozak sequence, and 12E10VHA (SEQ ID NO: 93) was designed to hybridize to the nucleotide sequence encoding C-terminal of H chain V region by the reverse primer and to have a splice donor sequence and BamHI restriction enzyme recognition site, respectively.

[0243] 100 µl of the PCR solution containing 10µl of 10 x PCR Gold Buffer II, 1.5mM MgCl₂, 0.08mM dNTPs (dATP, dGTP, dCTP, dTTP), 5 units of DNA-polymerase AmpliTaq Gold (all by PERKIN ELMER) and each 2.5pmole of each synthesized oligonucleotide (12B5VH-1 to -4) was heated at 94°C of the initial temperature for 9 minutes, at 94°C for 2 minutes, at 55°C for 2 minutes and 72°C for 2 minutes. After repeating the cycle two times each 100 pmole of external primer 12E10VHS and 12E10VHA were added. The mixture was subjected to the cycle consisting of at 94°C for 30 seconds, at 55°C for 30 seconds and 72°C for 1 minute 35 times and heated at 72°C for further 5 minutes.

[0244] The PCR product was purified by 1.5% low-melting-temperature agarose gel (Sigma), digested by restriction enzymes BamHI and Hind III, and cloned into a human H chain expression vector HEF-gy1. After determining the DNA sequence the plasmid containing the correct DNA sequence was named HEF-12E10H-gy1.

[0245] The HEF-12E10H-gy1 was digested by restriction enzymes EcoRI and BamHI to produce the gene encoding 12E10VH and then cloned into a human Fab H chain expression vector pCOS-Fd to produce pFd-12E10H. The human Fab H chain expression vector was constructed by amplifying the DNA (SEQ ID NO: 63) containing the intron region existing between the genes encoding human antibody H chain V region and the constant region, and the gene encoding a part of the human H chain constant region by PCR, and inserting the PCR product into animal cell expression vector pCOS1. The human H chain constant region was amplified for the gene under the same conditions mentioned above using as the template HEF-gy1, as the forward primer G1CH1-S (SEQ ID NO: 64) which was designed to hybridize to 5'-end sequence of intron 1 and to have restriction enzyme recognition sites EcoRI and BamHI and as the reverse primer G1CH1-A (SEQ ID NO: 65) which was designed to hybridize to 3'-end DNA of human H chain constant region CH1 domain and to have a sequence encoding a part of hinge region, two stop codons and restriction enzyme recognition site Bg1 II.

[0246] The nucleotide sequence and amino acid sequence of the reconstructed 12E10 H chain variable region which were included in plasmids HEF-12E10H-gy1 and pFd-12E10H are shown in SEQ ID NO: 94.

8.2 Construction of a gene encoding 12E10 L chain V region

[0247] The nucleotide sequence SEQ ID NO:96 was designed as a gene encoding L chain V region of human antibody 12E10 binding to human MPL on the basis of the amino acid sequence described in WO99/1049 (SEQ ID NO:95). It was further designed by connecting to its 5'-end the leader sequence (SEQ ID NO: 97) derived from human antibody gene (Mol. Immunol. 1992; 29: 1515-1518). In the same way as mentioned above the designed nucleotide sequence was divided into four oligonucleotides having overlapping sequences of 15 bp each (12E10VL1, 12E10VL2, 12E10VL3, 12E10VL4) and synthesized respectively. 12E10VL1 (SEQ ID NO: 98) and 12E10VL3 (SEQ ID NO: 100) had sense sequences, and 12E10VL2 (SEQ ID NO: 99) and 12E10VL4 (SEQ ID NO: 101) had antisense sequences, respectively. Each of the synthesized oligonucleotides was assembled by respective complementarity and mixed with the external primers (12E10VLS and 12E10VLA) to amplify the full length of the gene. 12E10VLS (SEQ ID NO: 102) was designed to hybridize to 5'-end of the leader sequence by the forward primer and to have EcoRI restriction enzyme recognition site and Kozak sequence. 12E10VLA (SEQ ID NO: 103) was designed to hybridize to the nucleotide sequence encoding C-terminal of L chain V region by the reverse primer and to have a BlnI restriction enzyme recognition site.

[0248] Performing the PCR as mentioned above, the PCR product was purified by 1.5% low-melting-temperature agarose gel (Sigma), digested by restriction enzymes EcoRI and BlnI, and cloned into pUC19 containing a gene for human lambda chain constant region. After determining the DNA sequence the plasmid containing the correct DNA sequence was digested by EcoRI to produce a gene encoding 12E10 L chain V region and human lambda chain constant region and then inserted in expression vector pCOS1. The plasmid having 12E10 L chain gene (SEQ ID NO: 104) was named pCOS-12E10L

8.3 Production of reconstructed 12E10 single chain Fv

[0249] The reconstructed 12E10 antibody single chain Fv was designed to be in the order of 12E10VH-linker-12E10VL and to have FLAG sequence (SEQ ID NO: 105) at C-terminal to facilitate the detection and purification. The reconstructed 12E10 chain Fvs (sc12E10 and db12E10) were constructed using a linker sequence consisting of 15 amino acids represented by (Gly₄Ser)₃ or 5 amino acids represented by (Gly₄Ser)₁.

(1) Production of the reconstructed 12E10 single chain Fv using the linker sequence consisting of 5 amino acids

[0250] The gene encoding the reconstructed 12E10 single chain Fv, which contained the linker sequence consisting of 5 amino acids, was constructed by introducing the nucleotide sequence for the linker (Gly₄Ser)₁ to 3'-end of the gene encoding 12E10 H chain V region and to 5'-end of the gene encoding 12E10 L chain V region, amplifying thus obtained respective gene by PCR and connecting the amplified genes. Four PCR primers (A-D) were used to produce the reconstructed 12E10 single chain Fv. Primers A and C had sense sequences, and primers B and D had antisense sequences.

[0251] The forward primer for H chain V region was 12E10S (Primer A, SEQ ID NO: 106). The reverse primer DB2 (Primer B, SEQ ID NO: 107) for H chain V region was designed to hybridize to DNA encoding C-terminal of H chain V region and to have the nucleotide sequence encoding the linker (Gly₄Ser)₁ and the nucleotide sequence encoding N-terminal of L chain V region.

[0252] The forward primer DB1 (Primer C, SEQ ID NO: 108) for L chain V region was designed to hybridize to DNA encoding the N-terminal of L chain V region and to have the nucleotide sequence encoding the linker (Gly₄Ser)₁ and the nucleotide sequence encoding C-terminal of H chain V region. The reverse primer 12E10FA (Primer D, SEQ ID NO: 109) for L chain V region was designed to hybridize to DNA encoding the C-terminal of L chain V region and to have the nucleotide sequence encoding FLAG and NotI restriction enzyme recognition site.

[0253] In the first PCR step, two reactions A-B and C-D were performed, and the two PCR products obtained from the first step PCR were assembled by respective complementarity. After adding primers A and D the full length DNA encoding the reconstructed 12E10 single chain Fv having the linker consisting of 5 amino acids was amplified (the second PCR). In the first step PCR, the plasmid HEF-12E10H-gy1 (see Example 8. 1) encoding the reconstructed 12E10 H chain V region and pCOS-12E10L (see Example 8.1) encoding the reconstructed 12E10 L chain V region were used as templates, respectively.

[0254] 50µl of the first step PCR solution contained 5µl of 10 x PCR Gold Buffer II, 1.5mM MgCl₂, 0.08mM dNTPs, 5 units of DNA polymerase AmpliTaq Gold (by PERKIN ELMER), each 100 pmole of each primer and 100ng of each template DNA. The PCR solution was heated at 94°C of the initial temperature for 9 minutes, at 94 for 30 seconds, 55°C for 30 seconds and 72°C for 1 minute. After repeating the cycle 35 times the reaction mixture was further heated at 72°C for 5 minutes.

[0255] The PCR products A-B (429bp) and C-D (395bp) were assembled by the second PCR. The second step PCR mixture solution (98µl) containing 1µl each of the first PCR product A-B and C-D as templates, 100 pmole each of each primer, 10µl of 10 x PCR Gold Buffer II, 1.5mM MgCl₂, 0.08mM dNTPs and 5 units of DNA polymerase AmpliTaq Gold (by PERKIN ELMER) was reacted under the same conditions as mentioned above.

[0256] The DNA fragment of 795bp produced by the second PCR was purified using 1.5% low-melting-temperature agarose gel, digested by EcoRI and NotI, and cloned into pCHO1 vector or pCOS1 vector. The expression vector pCHO1 was a vector constructed by deleting the antibody gene from DHFR-ΔE-RVH-PM1-f (see WO92/19759) by EcoRI and SmaI digestion, and connecting to EcoRI-NotI-BamHI Adaptor (TAKARA SHUZO). After determining the DNA sequence the plasmids containing the DNA fragment encoding the correct amino acid sequence of reconstructed 12B5 single chain Fv were named pCHO-db12E10 and pCOS-db12E10. The nucleotide sequence and amino acid sequence of the reconstructed 12E10 single chain Fv included in the plasmids pCHO-db12E1 and pCOS-db12E10 are shown in SEQ ID NO: 110.

(2) Production of the reconstructed 12E10 single chain Fv using the linker sequence consisting of 15 amino acids

[0257] The gene encoding the reconstructed 12E10 antibody single chain Fv, which contained the linker sequence consisting of 15 amino acids, was constructed by introducing the nucleotide sequence for the linker (Gly₄Ser)₃ to 3'-end of the gene encoding 12E10 H chain V region and to 5'-end of the gene encoding 12E10 L chain V region, amplifying thus obtained respective gene by PCR and connecting the amplified genes. Four PCR primers (A-D) were used for production of the reconstructed 12E10 single chain Fv. Primers A and C had sense sequences, and primers B and D had antisense sequences.

[0258] The forward primer for H chain V region was 12E10S (Primer A, SEQ ID NO: 106). The reverse primer sc4.3 (Primer B, SEQ ID NO: 111) for H chain V region was designed to hybridize to DNA encoding C-terminal of H chain V

region and to have the nucleotide sequence encoding the linker (Gly_4Ser)₃ and the nucleotide sequence encoding N-terminal of L chain V region.

[0259] The forward primer sc1.3 (Primer C, SEQ ID NO: 112) for L chain V region was designed to hybridize to DNA encoding the N-terminal of L chain V region and to have the nucleotide sequence encoding the linker (Gly_4Ser)₃ and the nucleotide sequence encoding C-terminal of H chain V region. The reverse primer 12E10FA (Primer D, SEQ ID NO: 109) for L chain V region was designed to hybridize to DNA encoding the C-terminal of L chain V region and to have the nucleotide sequence encoding FLAG and NotI restriction enzyme recognition site.

[0260] In the first PCR step, two reactions A-B and C-D were performed, and the two PCR products obtained from the first step PCR were assembled by respective complementarity. After adding primers A and D the full length DNA encoding the reconstructed 12E10 single chain Fv having the linker consisting of 15 amino acids was amplified (the second PCR). In the first step PCR, the plasmid pCOS-db12E10 (see Example 8. 1(1)) encoding the reconstructed 12E10 single chain Fv was used as template.

[0261] 50 μ l of the first step PCR solution contained 5 μ l of 10 x ExTaq Buffer, 0.4mM dNTPs, 2.5 units of DNA polymerase TaKaRa ExTaq (by TAKARA), each 100 pmole of each primer and 10ng of each template DNA. The PCR solution was heated at 94°C of the initial temperature for 30 seconds, at 94 for 15 seconds and 72°C for 2 minute, and the cycle was repeated 5 times. After repeating 28 times the cycle of at 94°C for 15 seconds and at 70°C for 2 minutes, the reaction mixture was further heated at 72°C for 5 minutes.

[0262] The PCR products A-B (477bp) and C-D (447bp) were assembled by the second PCR. The second step PCR mixture solution (98 μ l) containing 1 μ l each of the first PCR products A-B and C-D as templates, 100 pmole each of each primer A and D, 5 μ l of 10 x ExTaq Buffer, 0.4mM dNTPs, 2.5 units of DNA polymerase TaKaRa ExTaq (by TAKARA) was reacted under the same conditions as mentioned above.

[0263] The DNA fragment of 825bp produced by the second PCR was purified using 1.0% low-melting-temperature agarose gel, digested by EcoRI and NotI. Thus obtained DNA fragment was cloned into pCHO1 vector or pCOS1 vector. After determining the DNA sequence the plasmids containing the DNA fragment encoding the correct amino acid sequence of reconstructed 12E10 single chain Fv were named pCHO-sc12E10 and pCOS-sc12E10. The nucleotide sequence and amino acid sequence of the reconstructed 12E10 single chain Fv included in the plasmids pCHO-sc12E10 and pCOS-sc12E10 are shown in SEQ ID NO: 113.

8.4 Expression of antibody 12E10 (IgG, Fab) and single chain Fv polypeptide by animal cell

[0264] Antibody 12E10 (IgG, Fab) and single chain Fv derived from antibody 12E10 (linker sequence 5 amino acids, 15 amino acids) were expressed by using COS-7 cells or CHO cells.

[0265] The transient expression using COS-7 cells was performed as follows. The transfection was performed by electroporation method using Gene Pulser II equipment (BioRad). For the expression of antibody 12E10 (IgG) each 10 μ g of the above-mentioned expression vector HEF-12E10H-gy1 and pCOS-12E10L were added, for the expression of 12E10Fab fragment each 10 μ g of pFd-12E10H and pCOS-12E10L were added and for the expression of single chain Fv of pCOS-sc12E10 (10 μ g) or pCOS-db12E10 (10 μ g) was added to COS-7 cells (1 \times 10⁷ cells/ml) suspended in 0.8ml of PBS. The mixture kept in a cuvette was treated by pulse at the capacity of 1.5kV, 25 μ FD. After recovering for 10 minutes in a room temperature the electroporated cells were added to DMEM medium (GIBCO BRL) containing 10% bovine fetal serum and cultivated. After cultivating overnight the cells were washed once by PBS, added to serum-free medium CHO-S-SFM II (GIBCO BRL) and cultivated for 3 days. The culture supernatant was centrifuged to remove cell debris and filtered with 0.22 μ m filter.

[0266] To establish a stable expression CHO cell line for the single chain Fv (polypeptide) derived from antibody 12E10, the expression vector pCHO-sc12E10 or pCHO-ds12E10 was introduced into CHO cells respectively.

[0267] Each expression vector was introduced into CHO cells by electroporation method using Gene Pulser II equipment (BioRad). Linearized DNA (100 μ g) obtained by digestion with restriction enzyme Pvul and CHO cells (1 \times 10⁷ cells /ml) suspended in 0.8 ml of PBS were mixed in a cuvette, left stationary on ice for 10 minutes and treated with pulse at the capacity of 1.5kV, 25 μ FD. After recovering for 10 minutes at a room temperature the electroporated cells were added to CHO-S-SFM II medium (GIBCO BRL) containing 10% dialyzed bovine fetal serum and nucleic acid and cultivated. After cultivating for 2 days the cultivation was continued in nucleic acid-free CHO-S-SFM II medium (GIBCO BRL) containing 10% dialyzed bovine fetal serum. From thus obtained clones a clone with high expression rate was selected as the production cell line for 12E10 single chain Fv. After cultivating in serum-free CHO-S-SFM II medium (GIBCO BRL), the culture supernatant was centrifuged to remove cell debris and filtered with 0.22 μ m filter.

8.5 Purification of single chain Fv derived from 12E10 produced by CHO cells

[0268] The culture supernatants produced by CHO cell lines expressing 12E10 single chain Fvs (sc12E10 db12E10) obtained in Example 8.4 were purified by anti-FLAG antibody column and gel filtration column respectively to produce

purified single chain Fvs.

(1) Purification with anti-FLAG antibody column

- 5 [0269] Each culture supernatant (sc12E10 db12E10 was added to anti-FLAG M2 affinity gel column (SIGMA) equilibrated by 50mM Tris-HCl buffer (pH7.4) containing 150mM NaCl. After washing the column by the same buffer the proteins adsorbed to the column were eluted by 100mM glycine buffer (pH 3.5). The eluted fractions were immediately neutralized by adding 1M Tris-HCl buffer (pH 8.0) and analyzed by SDS-PAGE. The fraction which was confirmed to contain the single chain Fv was pooled and concentrated about 20-fold using Centricon-10 (AMICON).

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(2) Gel filtration

- 15 [0270] The concentrated solution obtained in (1) was added to Superdex200 column HR (10x300mm, AMERSHAM PHARMACIA) equilibrated by PBS containing 0.01% Tween20. Chlomatograms were shown in Fig. 53 and 54. The product sc12E10 was eluted in two peaks (A, B) (see Fig. 53). The product db12E10 was eluted in two peaks (C, D) (see Fig. 54). Each peak fraction was collected, treated in the presence and absence of a reducing agent, processed by electrophoresis according to Laemmli method and stained by Coomassie Brilliant Blue after the electrophoresis. As shown in Fig. 55 the all of fractions A, B, C and D, regardless of the presence or absence of the reducing agent, produced a single band having an apparent molecular weight of about 31 kD. When these fractions were analyzed by gel filtration using Superdex200 HR, the fraction A produced a product eluted at an apparent molecular weight of about 20 kD, the fraction B at 42kD (see Fig. 56), fraction C at 69kD and fraction D at 41kD (see Fig. 57). The results suggest that sc12E10-derived fraction A is the non-covalent bond dimer of single chain Fv and the fraction B is the monomer of single chain Fv, and the db12E10-derived fraction C is the non-covalent bond trimer of single chain Fv and D is non-covalent bond dimer of single chain Fv.

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8.6 Measurement of TPO-like agonist activity of various single chain Fvs

- 25 [0271] The TPO-like activity of anti-mpl single chain antibody was evaluated by measuring the proliferation activity to Ba/F3 cells (BaF/mpl) expressing human TPO receptor (MPL).

30 [0272] After washing BaF/mpl cells two times by RPMI1640 medium (GIBCO) containing 1% bovine fetal serum (GIBCO), the cells were suspended in the medium at cell density of 5×10^5 cells/mL. The anti-MPL single chain antibody or human TPO (R&D Systems) was diluted with the medium, respectively. 50 μ l of the cell suspension and 50 μ l of the diluted antibody or human TPO were added in 96-well microplate (flat bottom) (Corning), and cultivated in CO₂ incubator (CO₂ concentration: 5%) for 24 hours. After the incubation 10 μ l of WST-8 reagent (reagent for measuring the number of raw cells SF: Nacalai Tesque) was added and the absorbance was immediately measured at measurement wavelength of 450nm and at reference wavelength of 655nm using absorbency photometer Benchmark Plus (BioRad). After incubating in CO₂ incubator (CO₂ concentration: 5%) for 2 hours, the absorbance at 450nm of measurement wavelength and 655nm of reference wavelength was again measured using Benchmark Plus. Since WST-8 reagent developed the color reaction depending upon the number of live cells at wavelength of 450nm, the proliferation activity of BaF/mpl was evaluated based on the change of absorbance in 2 hours.

35 [0273] The agonist activity to MPL measured by using culture supernatants of COS-7 cells expressing various 12E10 antibody molecules are shown in Fig. 58. Single chain Fvs having the 5-amino-acid-linker (ds12E10 and the 15-amino-acid-linker (sc12E10 increased the absorbance in concentration-dependent manner, showing TPO-like agonist activity (ED50; 9pM and 51pM respectively), while 12E10 IgG and 12E10Fab had no activity.

40 [0274] It has been known that H chain and L chain of the single chain Fv are associated not only within a molecule but also between molecules to form multimers such as dimer. When the culture supernatants of CHO cells expressing single chain Fvs of 12E10 were gel filtrated and tested for agonist activity on MPL. The results were shown in Fig. 59. The dimer, which was contained in sc12E10 in a small amount, showed about 5000-fold stronger TPO-like agonist activity (sc12E10 dimer, ED50; 1.9pM) compared with the monomer (sc12E10 monomer, ED50; >10nM). The activity was higher than that of TPO (ED50; 27pM). The dimer of db12E10 (db12E10 dimer, ED50; 2.0pM) showed strong activity comparable to that of sc12E10 dimer. db12E10 trimer (ED50; 7.4pM), which was presumed to be a trimer from molecular weight obtained by gel filtration, showed a high activity which is lower than that of db12E10 dimer. Those results suggest that it is important for the activity of agonist antibody 12E10 that the antigen-binding site is bivalent (dimer). Considering the fact that 12E10 IgG had no activity, other factors than being bivalent are presumed to be important such as the location of antigen-binding site, the distance or the angle.

EXPLANATION OF DRAWINGS

[0275] Fig. 1 shows the result of flow cytometry, illustrating that human IgG antibody does not bind to L1210 cells expressing human IAP (hIAP/L1210).

5 [0276] Fig. 2 shows the result of flow cytometry, illustrating that the chimera MABL-1 antibody specifically binds to L1210 cells expressing human IAP (hIAP/L1210).

[0277] Fig. 3 shows the result of flow cytometry, illustrating that the chimera MABL-2 antibody specifically binds to L1210 cells expressing human IAP (hIAP/L1210).

[0278] Fig. 4 schematically illustrates the process for producing the single chain Fv according to the present invention.

10 [0279] Fig. 5 illustrates a structure of an expression plasmid which can be used to express a DNA encoding the single chain Fv of the invention in E. coli.

[0280] Fig. 6 illustrates a structure of an expression plasmid which is used to express a DNA encoding the single chain Fv of the invention in mammalian cells.

15 [0281] Fig. 7 shows the result of western blotting in Example 5.4. From the left, a molecular weight marker (which indicates 97.4, 66, 45, 31, 21.5 and 14.5 kDa from the top), the culture supernatant of pCHO1-introduced COS7 cells and the culture supernatant of pCHOM2-introduced COS7 cells. It illustrates that the reconstructed single chain Fv of the antibody MABL-2 (arrow) is contained in the culture supernatant of the pCHOM2-introduced cells.

[0282] Fig. 8 shows the result of flow cytometry, illustrating that an antibody in the culture supernatant of pCHO1/COS7 cell as a control does not bind to pCOS1/L1210 cell as a control.

20 [0283] Fig. 9 shows the result of flow cytometry, illustrating that an antibody in the culture supernatant of MABL2-scFv/ COS7 cells does not bind to pCOS1/L1210 cells as a control.

[0284] Fig. 10 shows the result of flow cytometry, illustrating that an antibody in the culture supernatant of pCOS1/COS7 cells as a control does not bind to hIAP/L1210 cells.

25 [0285] Fig. 11 shows the result of flow cytometry, illustrating that an antibody in the culture supernatant of MABL2-scFv/COS7 cells specifically binds to hIAP/L1210 cells.

[0286] Fig. 12 shows the result of the competitive ELISA in Example 5.6, wherein the binding activity of the single chain Fv of the invention (MABL2-scFv) to the antigen is demonstrated in terms of the inhibition of binding of the mouse monoclonal antibody MABL-2 to the antigen as an index, in comparison with the culture supernatant of pCHO1/COS7 cells as a control.

30 [0287] Fig. 13 shows the results of the apoptosis-inducing effect in Example 5.7, illustrating that the antibody in the culture supernatant of pCHO1/COS7 cells as a control does not induce apoptosis of pCOS1/L1210 cells as a control.

[0288] Fig. 14 shows the results of the apoptosis-inducing effect in Example 5.7, illustrating that the antibody in the culture supernatant of MABL2-scFv/COS7 cells does not induce apoptosis of pCOS1/L1210 cells as a control.

35 [0289] Fig. 15 shows the results of the apoptosis-inducing effect in Example 5.7, illustrating that the antibody in the culture supernatant of pCHO1/COS7 cells as a control does not induce apoptosis of hIAP/L1210 cells.

[0290] Fig. 16 shows the results of the apoptosis-inducing effect in Example 5.7, illustrating that the antibody in the culture supernatant of MABL2-scFv/COS7 cells specifically induces apoptosis of hIAP/L1210 cells.

40 [0291] Fig. 17 shows the results of the apoptosis-inducing effect in Example 5.7, illustrating that the antibody in the culture supernatant of pCHO1/COS7 cells as a control does not induce apoptosis of CCRF-CEM cells (at 50% of the final concentration).

[0292] Fig. 18 shows the results of the apoptosis-inducing effect in Example 5.7, illustrating that the antibody in the culture supernatant of MABL2-scFv/COS7 cells specifically induces apoptosis of CCRF-CEM cells (at 50% of the final concentration).

45 [0293] Fig. 19 shows the chromatogram obtained in the purification of the single chain Fv derived form the antibody MABL-2 produced by the CHO cells in Example 5.9, illustrating that fraction A and fraction B were obtained as the major peaks when the fraction from Blue-sepharose column was purified with hydroxyapatite column.

[0294] Fig. 20 shows the results of purification by gel filtration of fraction A and fraction B obtained in Example 5.9-(2), illustrating that the major peaks (Al and Bl, respectively) were eluted from fraction A at approximately 36 kD of the apparent molecular weight and from fraction B at approximately 76 kD.

50 [0295] Fig. 21 is the analysis on SDS-PAGE of the fractions obtained in the purification of the single chain Fv derived from the antibody MABL-2 produced by the CHO cells in Example 5.9, illustrating that a single band of approximately 35 kD of molecular weight was observed in both fractions.

[0296] Fig. 22 shows the results of analysis of fractions Al and Bl obtained by gel filtration in the purification of the single chain Fv derived from the antibody MABL-2 produced by the CHO cells, wherein fraction Al comprises monomer and fraction Bl comprises dimer.

55 [0297] Fig. 23 illustrates a structure of an expression plasmid which can be used to express a DNA encoding the single chain Fv of the invention in E. coli.

[0298] Fig. 24 shows the results of purification on the gel filtration column of crude products of the single chain Fv

polypeptide derived from the antibody MABL-2 produced by E. coli obtained in Example 5.12, wherein each peak indicates monomer or dimer, respectively, of the single chain Fv produced by E. coli.

[0299] Fig. 25 shows the results of the apoptosis-inducing effect in Example 5.13, illustrating that mouse IgG antibody as a control does not induce apoptosis of hIAP/L1210 cells (the final concentration of 3 µg/ml).

5 [0300] Fig. 26 shows the results of the apoptosis-inducing effect in Example 5.13, illustrating that the dimer of MABL2-scFv produced by the CHO cells remarkably induces apoptosis of hIAP/L1210 cells (the final concentration of 3 µg/ml).

[0301] Fig. 27 shows the results of the apoptosis-inducing effect in Example 5.13, illustrating that the dimer of MABL2-scFv produced by E. coli remarkably induces apoptosis of hIAP/L1210 cells (the final concentration of 3 µg/ml).

10 [0302] Fig. 28 shows the results of the apoptosis-inducing effect in Example 5.13, illustrating that apoptosis induction to hIAP/L1210 cells by the MABL2-scFv monomer produced by the CHO cells is the same level as that of the control (the final concentration of 3 µg/ml).

[0303] Fig. 29 shows the results of the apoptosis-inducing effect in Example 5.13, illustrating that apoptosis induction to hIAP/L1210 cells of the MABL2-scFv monomer produced by E. coli is the same level as that of control (the final concentration of 3 µg/ml).

15 [0304] Fig. 30 shows the results of the apoptosis-inducing effect in Example 5.13, illustrating that mouse IgG antibody used as a control does not induce apoptosis of hIAP/L1210 cells even when anti-FLAG antibody is added (the final concentration of 3 µg/ml).

20 [0305] Fig. 31 shows the results of the apoptosis-inducing effect in Example 5.13, illustrating that MABL2-scFv monomer produced by the CHO cells remarkably induces apoptosis of hIAP/L1210 cells when anti-FLAG antibody is added (the final concentration of 3 µg/ml).

[0306] Fig. 32 shows the results of quantitative measurement of human IgG in the serum of a human myeloma cell line KPMM2-transplanted mouse, indicating amounts of human IgG produced by the human myeloma cells in the mouse. It illustrates that the dimer of scFv/CHO remarkably inhibited growth of the KPMM2 cells.

25 [0307] Fig. 33 shows the survival time of the mouse after the transplantation of tumor, illustrating that the scFv/CHO dimer-administered group elongated remarkably the survival time.

[0308] Fig. 34 illustrates a structure of an expression plasmid which expresses a modified antibody [sc(Fv)₂] comprising two H chain V regions and two L chain V regions derived from the antibody MABL-2.

30 [0309] Fig. 35 illustrates a structure of a plasmid which expresses a scFv (HL type) wherein the V regions are linked in the manner of [H chain]-[L chain] without a peptide linker.

[0310] Fig. 36 illustrates a structure of the HL-type polypeptide and amino acid sequences of peptide linkers.

[0311] Fig. 37 illustrates a structure of a plasmid which expresses a scFv (LH type) wherein the V regions are linked in the manner of [L chain]-[H chain] without a peptide linker.

[0312] Fig. 38 illustrates a structure of the LH-type polypeptide and amino acid sequences of peptide linkers.

35 [0313] Fig. 39 shows the results of the western blotting in Example 6.4, illustrating that the modified antibody sc(FV)₂ comprising two H chain V regions and two L chain V regions, and the MABL2-scFv having peptide linkers with different length are expressed.

[0314] Figs. 40a and 40b show the results of flow cytometry using the culture supernatant of COS7 cells prepared in Example 6.3 (1), illustrating that the MABL2-scFv and sc(Fv)₂ having peptide linkers with different length have high affinities against human IAP.

40 [0315] Fig. 41 shows the results of the apoptosis-inducing effect in Example 6.6, illustrating that the scFv <HL3, 4, 6, 7, LH3, 4, 6 and 7> and the sc(Fv)₂ remarkably induce cell death of hIAP/L1210 cells.

[0316] Fig. 42 shows the results of the evaluation of antigen binding capacity in Example 6.10, illustrating that the dimer of scFv <HL5> and sc(Fv)₂ have high affinities against human IAP.

45 [0317] Fig. 43 shows the results of the *in vitro* apoptosis-inducing effect in Example 6.11, illustrating that the dimer of scFv <HL5> and the sc(Fv)₂ induce apoptosis of hIAP/L1210 cells and CCRF-CEM cells in concentration-dependent manner.

[0318] Fig. 44 shows the results of the quantitative measurement of M protein produced by a human myeloma cell line KPMM2 in the serum of the human myeloma cell-transplanted mouse. It illustrates that the dimer of scFv <HL5> and the sc(Fv)₂ remarkably inhibited growth of the KPMM2 cells.

[0319] Fig. 45 shows the survival time (days) of mice after the transplantation of tumor, illustrating that the survival time of the scFv <HL5> administrated-group was remarkably prolonged.

[0320] Fig. 46 shows the survival time (days) of mice after the transplantation of tumor, illustrating that the survival time of the sc(Fv)₂ administrated-group was remarkably prolonged.

55 [0321] Fig. 47 is a scheme showing the method for constructing DNA fragment encoding the reconstructed 12B5 single chain Fv containing the linker sequence consisting of 15 amino acids and the structure thereof.

[0322] Fig. 48 shows the purification result of each 12B5 single chain Fv by gel filtration obtained in Example 7. 5 (1), illustrating that sc12B5 was divided into two peaks (fractions A and B).

- [0323] Fig. 49 shows the analytical result of each fraction A and B by SDS-PAGE performed in Example 7. 5 (2).
- [0324] Fig. 50 shows the analytical result of each fraction A and B by Superdex200 column performed in Example 7. 5 (2), illustrating that the major peak of fraction A was eluted at an apparent molecular weight of about 44 kD shown in (a) and that the major peak of fraction B was eluted at an apparent molecular weight of about 22kD shown in (b).
- [0325] Fig. 51 shows the measurement result of the TPO-like agonist activity of sc12B5 and antibody 12B5 (IgG, Fab), illustrating that 12B5IgG and monovalent single chain Fv (sc12B5) showed TPO-like agonist activity in concentration-dependent manner.
- [0326] Fig. 52 shows the measurement result of TOP-like agonist activity of sc12B5 monomer and dimer, illustrating that single chain Fv (sc12B5 dimer) having bivalent antigen-binding site had agonist activity about 400-fold higher than monovalent sc12B5 and that the efficacy is equivalent to or higher than human TPO.
- [0327] Fig. 53 shows the purification result of obtained sc12E10 single chain antibody by gel filtration chromatography using Superdex200HR column, illustrating that 12E10sc3 was divided into two peaks (fractions A and B).
- [0328] Fig. 54 shows the purification result of obtained db12E10 single chain antibody by gel filtration chromatography using Superdex200HR column, illustrating that 12E10sc3 was divided into two peaks (fractions C and D).
- [0329] Fig. 55 shows SDS-PAGE analysis of fractions A and B (sc12E10 and fractions C and D (db12E10) under the reductive or non-reductive condition.
- [0330] Fig. 56 shows the analytical result of fractions A and B by gel filtration chromatography using Superdex200HR column, illustrating (1) the major peak of fraction A was eluted at an apparent molecular weight of about 42 kD and (2) the major peak of fraction B was eluted at an apparent molecular weight of about 20kD.
- [0331] Fig. 57 shows the analytical result of fractions C and D by gel filtration chromatography using Superdex200HR column, illustrating (1) the major peak of fraction C was eluted at an apparent molecular weight of about 69 kD and (2) the major peak of fraction B was eluted at an apparent molecular weight of about 41kD.
- [0332] Fig. 58 is a graph showing the agonist activity of various 12E10 antibody molecules on MPL, illustrating that single chain Fvs (sc12E10 db12E10) showed TPO-like agonist activity while 12E10 IgG and 12E10 Fab did not.
- [0333] Fig. 59 is a graph showing the agonist activity of monomer and dimer of sc12E10 and dimer and trimer of db12E10 on MPL, illustrating that dimer of sc12E10 and dimer and trimer of db12E10 showed higher TPO-like agonist activity than TPO.

INDUSTRIAL APPLICABILITY

[0334] The modified antibodies of the invention have an agonist action capable of transducing a signal into cells by crosslinking a cell surface molecule(s) and are advantageous in that the permeability to tissues and tumors is high due to the lowered molecular size compared with antibody molecule (whole IgG). This invention provides the modified antibodies with an agonist activity remarkably higher than TPO or parent antibodies (whole IgG). Especially even parent antibodies without agonist activity can be altered into the modified antibodies with an agonist activity higher than TPO. Therefore the modified antibodies can be used as signal-transducing agonists. The modification of antibody molecule results in the reduction of side effects caused by intercellular crosslinking and provides novel medicines inducing only required action by crosslinking a cell surface molecule(s). Medical preparations containing as active ingredient the modified antibodies of the invention are useful as preventives and/or remedies for platelet-related-blood diseases, thrombocytopenia caused by chemotherapy for cancers or leukemia and the like.

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 Met Lys Tyr Leu Leu Pro Thr Ala Ala Ala Gly Leu Leu Leu Ala
 10 1 5 10 15
 10 gcc caa cca gcc atg gcg cag gtc cag ctg cag cag tct gga cct gac 96
 Ala Gln Pro Ala Met Ala Gln Val Gln Leu Gln Gln Ser Gly Pro Asp
 15 20 25 30
 15 ctg gta aag cct ggg gct tca gtg aag atg tcc tgc aag gct tct gga 144
 Leu Val Lys Pro Gly Ala Ser Val Lys Met Ser Cys Lys Ala Ser Gly
 20 35 40 45
 20 tac acc ttc gtt aac cat gtt atg cac tgg gtg aag cag aag cca ggg 192
 Tyr Thr Phe Val Asn His Val Met His Trp Val Lys Gln Lys Pro Gly
 25 50 55 60
 25 cag ggc ctt gag tgg att gga tat att tat cct tac aat gat ggt act 240
 Gln Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Pro Tyr Asn Asp Gly Thr
 30 65 70 75 80
 30 aag tac aat gag aag ttc aag ggc aag gcc aca ctg act tca gag aaa 288
 Lys Tyr Asn Glu Lys Phe Lys Gly Lys Ala Thr Leu Thr Ser Glu Lys
 35 85 90 95
 35 tcc tcc agc gca gcc tac atg gag ctc agc agc ctg gcc tct gag gac 336
 Ser Ser Ser Ala Ala Tyr Met Glu Leu Ser Ser Leu Ala Ser Glu Asp
 40 100 105 110
 40 tct gcg gtc tac tac tgt gca aga ggg ggt tac tat agt tac gac gac 384
 Ser Ala Val Tyr Tyr Cys Ala Arg Gly Gly Tyr Tyr Ser Tyr Asp Asp
 45 115 120 125
 45 tgg ggc caa ggc acc act ctc aca gtc tcc tca ggt ggt ggt tcg 432
 Trp Gly Gln Gly Thr Thr Leu Thr Val Ser Ser Gly Gly Gly Ser
 50 130 135 140

ggt ggt ggt ggt tcg ggt ggc gga tcg gat gtt gtg atg acc caa 480
 Gly Gly Gly Gly Ser Gly Gly Gly Ser Asp Val Val Met Thr Gln
 5 145 150 155 160
 act cca ctc tcc ctg cct gtc agt ctt gga gat caa gcc tcc atc tct 528
 10 Thr Pro Leu Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile Ser
 165 170 175
 tgc aga tct agt cag agc ctt cta cac agt aaa gga aac acc tat tta 576
 15 Cys Arg Ser Ser Gln Ser Leu Leu His Ser Lys Gly Asn Thr Tyr Leu
 180 185 190
 20 caa tgg tac cta cag aag cca ggc cag tct cca aag ctc ctg atc tac 624
 Gln Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile Tyr
 195 200 205
 25 aaa gtt tcc aac cga ttt tct ggg gtc cca gac agg ttc agt ggc agt 672
 Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser
 30 210 215 220
 gga tca ggg acá gat ttc aca ctc aag atc agc aga gtg gag gct gag 720
 Gly Ser Gly Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu
 35 225 230 235 240
 gat ctg gga gtt tat ttc tgc tct caa agt aca cat gtt ccg tac acg 768
 40 Asp Leu Gly Val Tyr Phe Cys Ser Gln Ser Thr His Val Pro Tyr Thr
 245 250 255
 tcc gga ggg ggg acc aag ctg gaa ata aaa gac tac aaa gac gat gac 816
 45 Ser Gly Gly Thr Lys Leu Glu Ile Lys Asp Tyr Lys Asp Asp Asp
 260 265 270
 50 gat aaa taatga 828
 Asp Lys

5 <211> 31

<212> DNA

10 <213> Artificial Sequence

<220>

15 <223> PCR primer

<400> 21

15 acgcgtcgac tcccaggtcc agctgcagca g 31

20 <210> 22

<211> 18

<212> DNA

25 <213> Artificial Sequence

<220>

30 <223> PCR primer

<400> 22

30 gaaggtgtat ccagaagc 18

35 <210> 23

<211> 819

40 <212> DNA

<213> Mus

<220>

45 <221> CDS

<222> (1)...(813)

50 <223> pCHOM1. MABL1-scFv

<400> 23

55 atg gga tgg agc tgt atc atc ctc ttc ttg gta gca aca gct aca ggt 48

Met Gly Trp Ser Cys Ile Ile Leu Phe Leu Val Ala Thr Ala Thr Gly

	1	5	10	15
5	gtc gac tcc cag gtc cag ctg cag cag tct gga cct gac ctg gta aag			96
	Val Asp Ser Gln Val Gln Leu Gln Gln Ser Gly Pro Asp Leu Val Lys			
10		20	25	30
	cct ggg gct tca gtg aag atg tcc tgc aag gct tct gga tac acc ttc			144
	Pro Gly Ala Ser Val Lys Met Ser Cys Lys Ala Ser Gly Tyr Thr Phe			
15		35	40	45
	gtt aac cat gtt atg cac tgg gtg aag cag aag cca ggg cag ggc ctt			192
	Val Asn His Val Met His Trp Val Lys Gln Lys Pro Gly Gln Gly Leu			
20		50	55	60
	gag tgg att gga tat att tat cct tac aat gat ggt act aag tac aat			240
	Glu Trp Ile Gly Tyr Ile Tyr Pro Tyr Asn Asp Gly Thr Lys Tyr Asn			
25		65	70	75
	gag aag ttc aag ggc aag gcc aca ctg act tca gag aaa tcc tcc agc			288
	Glu Lys Phe Lys Gly Lys Ala Thr Leu Thr Ser Glu Lys Ser Ser Ser			
30		85	90	95
	gca gcc tac atg gag ctc agc agc ctg gcc tct gag gac tct gcg gtc			336
35		Ala Ala Tyr Met Glu Leu Ser Ser Leu Ala Ser Glu Asp Ser Ala Val		
		100	105	110
40	tac tac tgt gca aga ggg ggt tac tat agt tac gac gac tgg ggc caa			384
	Tyr Tyr Cys Ala Arg Gly Gly Tyr Tyr Ser Tyr Asp Asp Trp Gly Gln			
		115	120	125
45	ggc acc act ctc aca gtc tcc tca ggt ggt ggt tcg ggt ggt ggt			432
	Gly Thr Thr Leu Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly			
50		130	135	140
	ggt tcg ggt ggt ggc gga tcg gat gtt gtg atg acc caa act cca ctc			480
	Gly Ser Gly Gly Gly Ser Asp Val Val Met Thr Gln Thr Pro Leu			
55		145	150	155
				160

tcc ctg cct gtc agt ctt gga gat caa gcc tcc atc tct tgc aga tct 528
 Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile Ser Cys Arg Ser
 5 165 170 175

 agt cag agc ctt cta cac agt aaa gga aac acc tat tta caa tgg tac 576
 10 Ser Gln Ser Leu Leu His Ser Lys Gly Asn Thr Tyr Leu Gln Trp Tyr
 180 185 190

 cta cag aag cca ggc cag tct cca aag ctc ctg atc tac aaa gtt tcc 624
 15 Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile Tyr Lys Val Ser
 195 200 205

 aac cga ttt tct ggg gtc cca gac agg ttc agt ggc agt gga tca ggg 672
 20 Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly
 210 215 220

 aca gat ttc aca ctc aag atc agc aga gtg gag gct gag gat ctg gga 720
 25 Thr Asp Phe Thr Leu Lys Ile Ser Arg Val Glu Ala Glu Asp Leu Gly
 225 230 235 240

 gtt tat ttc tgc tct caa agt aca cat gtt ccg tac acg tcc gga ggg 768
 30 Val Tyr Phe Cys Ser Gln Ser Thr His Val Pro Tyr Thr Ser Gly Gly
 245 250 255

 ggg acc aag ctg gaa ata aaa gac tac aaa gac gat gac gat aaa taa 816
 35 Gly Thr Lys Leu Glu Ile Lys Asp Tyr Lys Asp Asp Asp Lys
 260 265 270

 tga 819
 40
 <210> 24
 <211> 828
 50 <212> DNA
 <213> Mus
 55 <220>

<221> CDS

<222> (1)...(822)

<223> pscM2, MABL2-scFv

<400> 24

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Met Lys Tyr Leu Leu Pro Thr Ala Ala Ala Gly Leu Leu Leu Ala

1 5 10 15

gcc caa cca gcc atg gcg cag gtc cag ctg cag cag tct gga cct gaa 96

Ala Gln Pro Ala Met Ala Gln Val Gln Leu Gln Gln Ser Gly Pro Glu

20 25 30

ctg gta aag cct ggg gct tca gtg aag atg tcc tgc aag gct tct gga 144

Leu Val Lys Pro Gly Ala Ser Val Lys Met Ser Cys Lys Ala Ser Gly

25 35 40 45

tac acc ttc gct aac cat gtt att cac tgg gtg aag cag aag cca ggg 192

Tyr Thr Phe Ala Asn His Val Ile His Trp Val Lys Gln Lys Pro Gly

30 50 55 60

cag ggc ctt gag tgg att gga tat att tat cct tac aat gat ggt act 240

35 Gln Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Pro Tyr Asn Asp Gly Thr

65 70 75 80

aag tat aat gag aag ttc aag gac aag gcc act ctg act tca gac aaa 288

40 Lys Tyr Asn Glu Lys Phe Lys Asp Lys Ala Thr Leu Thr Ser Asp Lys

85 90 95

45 tcc tcc acc aca gcc tac atg gac ctc agc agc ctg gcc tct gag gac 336

Ser Ser Thr Thr Ala Tyr Met Asp Leu Ser Ser Leu Ala Ser Glu Asp

50 100 105 110

tct gcg gtc tat tac tgt gca aga ggg ggt tac tat act tac gac gac 384

55 Ser Ala Val Tyr Tyr Cys Ala Arg Gly Gly Tyr Tyr Thr Tyr Asp Asp

115 120 125

tgg ggc caa ggc acc act ctc aca gtc tcc tca ggt ggt ggt tcg 432
 Trp Gly Gln Gly Thr Thr Leu Thr Val Ser Ser Gly Gly Gly Ser
 5 130 135 140

 ggt ggt ggt ggt tcg ggt ggc gga tcg gat gtt gtg atg acc caa 480
 Gly Gly Gly Ser Gly Gly Ser Asp Val Val Met Thr Gln
 10 145 150 155 160

 agt cca ctc tcc ctg cct gtc agt ctt gga gat caa gcc tcc atc tct 528
 15 Ser Pro Leu Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile Ser

 165 170 175

 tgc aga tca agt cag agc ctt gtg cac agt aat gga aag acc tat tta 576
 Cys Arg Ser Ser Gln Ser Leu Val His Ser Asn Gly Lys Thr Tyr
 20 180 185 190

 cat tgg tac ctg cag aag cca ggc cag tct cca aaa ctc ctg atc tac 624
 His Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile Tyr
 25 195 200 205

 aaa gtt tcc aac cga ttt tct ggg gtc cca gac agg ttc agt ggc agt 672
 Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser
 30 210 215 220

 gga tca gtg aca gat ttc aca ctc atg atc agc aga gtg gag gct gag 720
 Gly Ser Val Thr Asp Phe Thr Leu Met Ile Ser Arg Val Glu Ala Glu
 35 225 230 235 240

 gat ctg gga gtt tat ttc tgc tct caa agt aca cat gtt ccg tac acg 768
 Asp Leu Gly Val Tyr Phe Cys Ser Gln Ser Thr His Val Pro Tyr Thr
 40 245 250 255

 ttc gga ggg ggg acc aag ctg gaa ata aaa gac tac aaa gac gat gac 816
 Phe Gly Gly Thr Lys Leu Glu Ile Lys Asp Tyr Lys Asp Asp Asp
 45 260 265 270

 50 gat aaa taatga 828

Asp Lys

5 <210> 25
10 <211> 819
15 <212> DNA
20 <213> Mus.
<220>
25 <221> CDS
30 <222> (1)...(813)
35 <223> pCHOM2. MABL2-scFv
40 <400> 25
45 atg gga tgg agc tgt atc atc ctc ttc ttg gta gca aca gct aca ggt 48
Met Gly Trp Ser Cys Ile Ile Leu Phe Leu Val Ala Thr Ala Thr Gly
50 1 5 10 15
55 gtc gac tcc cag gtc cag ctg cag cag tct gga cct gaa ctg gta aag 96
Val Asp Ser Gln Val Gln Leu Gln Gln Ser Gly Pro Glu Leu Val Lys
60 20 25 30
65 cct ggg gct tca gtg aag atg tcc tgc aag gct tct gga tac acc ttc 144
Pro Gly Ala Ser Val Lys Met Ser Cys Lys Ala Ser Gly Tyr Thr Phe
70 35 40 45
75 gct aac cat gtt att cac tgg gtg aag cag aag cca ggg cag ggc ctt 192
Ala Asn His Val Ile His Trp Val Lys Gln Lys Pro Gly Gln Gly Leu
80 50 55 60
85 gag tgg att gga tat att tat cct tac aat gat ggt act aag tat aat 240
Glu Trp Ile Gly Tyr Ile Tyr Pro Tyr Asn Asp Gly Thr Lys Tyr Asn
90 65 70 75 80
95 gag aag ttc aag gac aag gcc act ctg act tca gac aaa tcc tcc acc 288
Glu Lys Phe Lys Asp Lys Ala Thr Leu Thr Ser Asp Lys Ser Ser Thr

	85	90	95
5	aca gcc tac atg gac ctc agc agc ctg gcc tct gag gac tct gcg gtc	336	
	Thr Ala Tyr Met Asp Leu Ser Ser Leu Ala Ser Glu Asp Ser Ala Val		
	100	105	110
10	tat tac tgt gca aga ggg ggt tac tat act tac gac gac tgg ggc caa	384	
	Tyr Tyr Cys Ala Arg Gly Gly Tyr Tyr Thr Tyr Asp Asp Trp Gly Gln		
	115	120	125
15	ggc acc act ctc aca gtc tcc tca ggt ggt ggt tcg ggt ggt ggt	432	
	Gly Thr Thr Leu Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly		
20	130	135	140
	ggt tcg ggt ggt ggc gga tcg gat gtt gtg atg acc caa agt cca ctc	480	
	Gly Ser Gly Gly Ser Asp Val Val Met Thr Gln Ser Pro Leu		
25	145	150	155
	tcc ctg cct gtc agt ctt gga gat caa gcc tcc atc tct tgc aga tca	528	
	Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile Ser Cys Arg Ser		
30	165	170	175
	agt cag agc ctt gtg cac agt aat gga aag acc tat tta cat tgg tac	576	
35	Ser Gln Ser Leu Val His Ser Asn Gly Lys Thr Tyr Leu His Trp Tyr		
	180	185	190
40	ctg cag aag cca ggc cag tct cca aaa ctc ctg atc tac aaa gtt tcc	624	
	Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile Tyr Lys Val Ser		
	195	200	205
45	aac cga ttt tct ggg gtc cca gac agg ttc agt ggc agt gga tca gtg	672	
	Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Val		
	210	215	220
50	aca gat ttc aca ctc atg atc agc aga gtg gag gct gag gat ctg gga	720	
	Thr Asp Phe Thr Leu Met Ile Ser Arg Val Glu Ala Glu Asp Leu Gly		
55	225	230	235
	240		

gtt tat ttc tgc tct caa agt aca cat gtt ccg tac acg ttc gga ggg 768
 Val Tyr Phe Cys Ser Gln Ser Thr His Val Pro Tyr Thr Phe Gly Gly
 5 245 250 255
 ggg acc aag ctg gaa ata aaa gac tac aaa gac gat gac gat aaa taa 816
 10 Gly Thr Lys Leu Glu Ile Lys Asp Tyr Lys Asp Asp Asp Asp Lys
 260 265 270
 tga 819
 15
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 20 <211> 456
 <212> DNA
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 25 <220>
 <221> CDS
 30 <222> (1)...(450)
 <223> pCHO-shIAP. Soluble human IAP
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 35 atg tgg ccc ctg gta gcg gcg ctg ttg ctg ggc tcg gcg tgc tgc gga 48
 Met Trp Pro Leu Val Ala Ala Leu Leu Leu Gly Ser Ala Cys Cys Gly
 40 1 5 10 15
 tca gct cag cta cta ttt aat aaa aca aaa tct gta gaa ttc acg ttt 96
 Ser Ala Gln Leu Leu Phe Asn Lys Thr Lys Ser Val Glu Phe Thr Phe
 45 20 25 30
 tgt aat gac act gtc gtc att cca tgc ttt gtt act aat atg gag gca 144
 Cys Asn Asp Thr Val Val Ile Pro Cys Phe Val Thr Asn Met Glu Ala
 50 35 40 45
 caa aac act act gaa gta tac gta aag tgg aaa ttt aaa gga aga gat 192
 55 Gln Asn Thr Thr Glu Val Tyr Val Lys Trp Lys Phe Lys Gly Arg Asp

	50	55	60	
5	att tac acc ttt gat gga gct cta aac aag tcc act gtc ccc act gac			240
	Ile Tyr Thr Phe Asp Gly Ala Leu Asn Lys Ser Thr Val Pro Thr Asp			
	65	70	75	80
10	ttt agt agt gca aaa att gaa gtc tca caa tta cta aaa gga gat gcc			288
	Phe Ser Ser Ala Lys Ile Glu Val Ser Gln Leu Leu Lys Gly Asp Ala			
15	85	90	95	
	tct ttg aag atg gat aag agt gat gct gtc tca cac aca gga aac tac			336
	Ser Leu Lys Met Asp Lys Ser Asp Ala Val Ser His Thr Gly Asn Tyr			
20	100	105	110	
	act tgt gaa gta aca gaa tta acc aga gaa ggt gaa acg atc atc gag			384
	Thr Cys Glu Val Thr Glu Leu Thr Arg Glu Gly Glu Thr Ile Ile Glu			
25	115	120	125	
	cta aaa tat cgt gtt tca tgg ttt tct cca aat gaa aat gac tac			432
30	Leu Lys Tyr Arg Val Val Ser Trp Phe Ser Pro Asn Glu Asn Asp Tyr			
	130	135	140	
	aag gac gac gat gac aag tgata			456
35	Lys Asp Asp Asp Asp Lys			
	145	150		
40	<210> 27			
	<211> 46			
45	<212> DNA			
	<213> Artificial Sequence			
50	<220>			
	<223> PCR primer			
	<400> 27			
55	ggaattccat atgcaagtgc aacttcaaca gtctggacct gaactg			46

5 <210> 28
 <211> 31
 <212> DNA
 10 <213> Artificial Sequence

15 <220>
 <223> PCR primer
 <400> 28

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20 <210> 29

<211> 741

25 <212> DNA

<213> Mus

<220>

30 <221> CDS

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35 <223> pscM2DEm02. MABL2-scFv

<400> 29

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Met Gln Val Gln Leu Gln Gln Ser Gly Pro Glu Leu Val Lys Pro Gly

45 1 5 10 15

gct tca gtg aag atg tcc tgc aag gct tct gga tac acc ttc gct aac 96

Ala Ser Val Lys Met Ser Cys Lys Ala Ser Gly Tyr Thr Phe Ala Asn

50 20 25 30

cat gtt att cac tgg gtg aag cag aag cca ggg cag ggc ctt gag tgg 144

His Val Ile His Trp Val Lys Gln Lys Pro Gly Gln Gly Leu Glu Trp

55 35 40 45

att gga tat att tat cct tac aat gat ggt act aag tat aat gag aag 192
 Ile Gly Tyr Ile Tyr Pro Tyr Asn Asp Gly Thr Lys Tyr Asn Glu Lys
 5 50 55 60
 ttc aag gac aag gcc act ctg act tca gac aaa tcc tcc acc aca gcc 240
 Phe Lys Asp Lys Ala Thr Leu Thr Ser Asp Lys Ser Ser Thr Thr Ala
 10 65 70 75 80
 tac atg gac ctc agc agc ctg gcc tct gag gac tct gcg gtc tat tac 288
 Tyr Met Asp Leu Ser Ser Leu Ala Ser Glu Asp Ser Ala Val Tyr Tyr
 15 85 90 95
 tgt gca aga ggg ggt tac tat act tac gac gac tgg ggc caa ggc acc 336
 Cys Ala Arg Gly Gly Tyr Tyr Thr Tyr Asp Asp Trp Gly Gln Gly Thr
 20 100 105 110
 act ctc aca gtc tcc tca ggt ggt ggt tcg ggt ggt ggt tcg 384
 Thr Leu Thr Val Ser Ser Gly Gly Ser Gly Gly Ser Gly Ser
 25 115 120 125
 ggt ggt ggc gga tcg gat gtt gtg atg acc caa agt cca ctc tcc ctg 432
 Gly Gly Gly Ser Asp Val Val Met Thr Gln Ser Pro Leu Ser Leu
 30 130 135 140
 cct gtc agt ctt gga gat caa gcc tcc atc tct tgc aga tca agt cag 480
 Pro Val Ser Leu Gly Asp Gln Ala Ser Ile Ser Cys Arg Ser Ser Gln
 35 145 150 155 160
 agc ctt gtg cac agt aat gga aag acc tat tta cat tgg tac ctg cag 528
 Ser Leu Val His Ser Asn Gly Lys Thr Tyr Leu His Trp Tyr Leu Gln
 40 165 170 175
 aag cca ggc cag tct cca aaa ctc ctg atc tac aaa gtt tcc aac cga 576
 Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile Tyr Lys Val Ser Asn Arg
 45 180 185 190
 ttt tct ggg gtc cca gac agg ttc agt ggc agt gga tca gtg aca gat 624
 50
 55

Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ser Val Thr Asp

195 200 205

ttc aca ctc atg atc agc aga gtg gag gct gag gat ctg gga gtt tat 672

Phe Thr Leu Met Ile Ser Arg Val Glu Ala Glu Asp Leu Gly Val Tyr

210 215 220

ttc tgc tct caa agt aca cat gtt ccg tac acg ttc gga ggg ggg acc 720

Phe Cys Ser Gln Ser Thr His Val Pro Tyr Thr Phe Gly Gly Thr

225 230 235 240

aag ctg gaa ata aaa taatga 741

Lys Leu Glu Ile Lys

245

25 <210> 30

<211> 18

30 <212> DNA

<213> Artificial Sequence

<220>

35 <223> PCR primer

<400> 30

40 cagacagtgg ttcaaagt 18

65 <210> 31

45 <211> 72

<212> DNA

50 <213> Artificial Sequence

<220>

55 <223> PCR primer

<400> 31

cgcgtcgacc gatccgccac cacccgaacc accaccaccc gaaccaccac cacctttat 60
 ttccagctt g t 72
 5

<210> 32
 10 <211> 1605
 <212> DNA
 15 <213> Mus
 <220>
 <221> CDS
 20 <222> (1)...(1599)
 <223> pCHOM2(Fv)2. MABL2-sc(Fv)2

25 <400> 32
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 Met Gly Trp Ser Cys Ile Ile Leu Phe Leu Val Ala Thr Ala Thr Gly
 30 1 5 10 15

gtc gac tcc cag gtc cag ctg cag cag tct gga cct gaa ctg gta aag 96
 Val Asp Ser Gln Val Gln Leu Gln Gln Ser Gly Pro Glu Leu Val Lys
 35 20 25 30

cct ggg gct tca gtg aag atg tcc tgc aag gct tct gga tac acc ttc 144
 Pro Gly Ala Ser Val Lys Met Ser Cys Lys Ala Ser Gly Tyr Thr Phe
 40 35 40 45

gct aac cat gtt att cac tgg gtg aag cag aag cca ggg cag ggc ctt 192
 Ala Asn His Val Ile His Trp Val Lys Gln Lys Pro Gly Gln Gly Leu
 45 50 55 60

gag tgg att gga tat att tat cct tac aat gat ggt act aag tat aat 240
 Glu Trp Ile Gly Tyr Ile Tyr Pro Tyr Asn Asp Gly Thr Lys Tyr Asn
 50 65 70 75 80

55 gag aag ttc aag gac aag gcc act ctg act tca gac aaa tcc tcc acc 288

Glu Lys Phe Lys Asp Lys Ala Thr Leu Thr Ser Asp Lys Ser Ser Thr
 5 85 90 95
 aca gcc tac atg gac ctc agc agc ctg gcc tct gag gac tct gcg gtc 336
 Thr Ala Tyr Met Asp Leu Ser Ser Leu Ala Ser Glu Asp Ser Ala Val
 10 100 105 110
 tat tac tgt gca aga ggg ggt tac tat act tac gac gac tgg ggc caa 384
 Tyr Tyr Cys Ala Arg Gly Gly Tyr Tyr Thr Tyr Asp Asp Trp Gly Gln
 15 115 120 125
 ggc acc act ctc aca gtc tcc tca ggt ggt ggt tcg ggt ggt ggt 432
 Gly Thr Thr Leu Thr Val Ser Ser Gly Gly Gly Ser Gly Gly Gly
 20 130 135 140
 ggt tcg ggt ggc gga tcg gat gtt gtg atg acc caa agt cca ctc 480
 25 Gly Ser Gly Gly Ser Asp Val Val Met Thr Gln Ser Pro Leu
 145 150 155 160
 tcc ctg cct gtc agt ctt gga gat caa gcc tcc atc tct tgc aga tca 528
 Ser Leu Pro Val Ser Leu Gly Asp Gln Ala Ser Ile Ser Cys Arg Ser
 30 165 170 175
 agt cag agc ctt gtg cac agt aat gga aag acc tat tta cat tgg tac 576
 Ser Gln Ser Leu Val His Ser Asn Gly Lys Thr Tyr Leu His Trp Tyr
 35 180 185 190
 ctg cag aag cca ggc cag tct cca aaa ctc ctg atc tac aaa gtt tcc 624
 Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu Leu Ile Tyr Lys Val Ser
 40 195 200 205
 aac cga ttt tct ggg gtc cca gac agg ttc agt ggc agt gga tca gtg 672
 Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Val
 45 210 215 220
 aca gat ttc aca ctc atg atc agc aga gtg gag gct gag gat ctg gga 720
 Thr Asp Phe Thr Leu Met Ile Ser Arg Val Glu Ala Glu Asp Leu Gly
 50 55

225	230	235	240
5	gtt tat ttc tgc tct caa agt aca cat gtt cog tac acg ttc gga ggg		768
	Val Tyr Phe Cys Ser Gln Ser Thr His Val Pro Tyr Thr Phe Gly Gly		
10	245	250	255
	ggg acc aag ctg gaa ata aaa ggt ggt ggt tcg ggt ggt ggt ggt		816
	Gly Thr Lys Leu Glu Ile Lys Gly Gly Ser Gly Gly Gly		
15	260	265	270
	tcg ggt ggt ggc gga tcg gtc gac tcc cag gtc cag ctg cag cag tct		864
	Ser Gly Gly Gly Ser Val Asp Ser Gln Val Gln Leu Gln Gln Ser		
20	275	280	285
	gga cct gaa ctg gta aag cct ggg gct tca gtg aag atg tcc tgc aag		912
	Gly Pro Glu Leu Val Lys Pro Gly Ala Ser Val Lys Met Ser Cys Lys		
25	290	295	300
	gct tct gga tac acc ttc gct aac cat gtt att cac tgg gtg aag cag		960
	Ala Ser Gly Tyr Thr Phe Ala Asn His Val Ile His Trp Val Lys Gln		
30	305	310	315
	aag cca ggg cag ggc ctt gag tgg att gga tat att tat cct tac aat		1008
35	Lys Pro Gly Gln Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Pro Tyr Asn		
	325	330	335
40	gat ggt act aag tat aat gag aag ttc aag gac aag gcc act ctg act		1056
	Asp Gly Thr Lys Tyr Asn Glu Lys Phe Lys Asp Lys Ala Thr Leu Thr		
	340	345	350
45	tca gac aaa tcc tcc acc aca gcc tac atg gac ctc agc agc ctg gcc		1104
	Ser Asp Lys Ser Ser Thr Thr Ala Tyr Met Asp Leu Ser Ser Leu Ala		
50	355	360	365
	tct gag gac tct gcg gtc tat tac tgt gca aga ggg ggt tac tat act		1152
	Ser Glu Asp Ser Ala Val Tyr Tyr Cys Ala Arg Gly Gly Tyr Tyr Thr		
55	370	375	380

tac gac gac tgg ggc caa ggc acc act ctc aca gtc tcc tca ggt ggt 1200
 Tyr Asp Asp Trp Gly Gln Gly Thr Thr Leu Thr Val Ser Ser Gly Gly
 5 385 390 395 400
 ggt ggt tcg ggt ggt ggt tcg ggt ggt ggc gga tcg gat gtt gtg 1248
 10 Gly Gly Ser Gly Gly Ser Gly Gly Ser Gly Gly Ser Asp Val Val
 405 410 415
 atg acc caa agt cca ctc tcc ctg cct gtc agt ctt gga gat caa gcc 1296
 15 Met Thr Gln Ser Pro Leu Ser Leu Pro Val Ser Leu Gly Asp Gln Ala
 420 425 430
 tec atc tct tgc aga tca agt cag agc ctt gtg cac agt aat gga aag 1344
 20 Ser Ile Ser Cys Arg Ser Ser Gln Ser Leu Val His Ser Asn Gly Lys
 435 440 445
 acc tat tta cat tgg tac ctg cag aag cca ggc cag tct cca aaa ctc 1392
 25 Thr Tyr Leu His Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu
 450 455 460
 ctg atc tac aaa gtt tcc aac cga ttt tct ggg gtc cca gac agg ttc 1440
 Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe
 30 465 470 475 480
 agt ggc agt gga tca gtg aca gat ttc aca ctc atg atc agc aga gtg 1488
 35 Ser Gly Ser Gly Ser Val Thr Asp Phe Thr Leu Met Ile Ser Arg Val
 485 490 495
 gag gct gag gat ctg gga gtt tat ttc tgc tct caa agt aca cat gtt 1536
 40 Glu Ala Glu Asp Leu Gly Val Tyr Phe Cys Ser Gln Ser Thr His Val
 500 505 510
 ccg tac acg ttc gga ggg ggg acc aag ctg gaa ata aaa gac tac aaa 1584
 45 Pro Tyr Thr Phe Gly Gly Thr Lys Leu Glu Ile Lys Asp Tyr Lys
 515 520 525
 55 gac gat gac gat aaa taatga 1605

Asp Asp Asp Asp Lys

5 530

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60 cacgacgtca ctcgagactg tgagagtgg gccttggccc 40

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70 <211> 40

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80 <400> 35

5 agtctcgagt gacgtcgtga tgacccaaag tccactctcc 40

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20 gactggatcc tcattattta tcgtcatcgt c 31

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35 <400> 37
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40 <210> 38
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45 <212> DNA
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55 gcaattggac ctgttttatac tcgagcttgg tccccctcc gaacgt 46

5 <210> 39

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<212> DNA

10 <213> Artificial Sequence

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15 <400> 39

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20 <210> 40

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25 <212> DNA

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30 <223> PCR primer

<400> 40

35 gactggatcc tcattattta tcgtcatcgt cttttagtc tgaggagact gtgagagtgg 60

40 <210> 41

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45 <213> Artificial Sequence

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50 <400> 41

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5 <210> 42
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5 <212> DNA
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10 <220>
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15 <400> 42
15 cagtctcgag tggtggttcc gacgtcgtga tgacctaaag 40

20 <210> 43
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20 <212> DNA
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35

40 <210> 44
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50 cagtctcgag tggtggtggt ggttccgacg tcgtgatgac ccaaag 46

55 <210> 45

5 <211> 49

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20 <210> 46

<211> 52

<212> DNA

25 <213> Artificial Sequence

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30 <223> PCR primer

<400> 46

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35 <210> 47

<211> 20

40 <212> DNA

<213> Artificial Sequence

<220>

45 <223> PCR primer

<400> 47

50 ggccgcatgt tgtcacgaat 20

55 <210> 48

<211> 780

<212> DNA

5 <213> Mus

<220>

10 <221> CDS

<222> (1)...(768)

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MET Gly Trp Ser Cys Ile Ile Leu Phe Leu Val Ala Thr Ala Thr Gly Val

20 5 10 15

gac tcc cag gtc cag ctg cag cag tct gga cct gaa ctg gta aag cct ggg 102
Asp Ser Gln Val Gln Leu Gln Gln Ser Gly Pro Glu Leu Val Lys Pro Gly

25 20 25 30

gct tca gtg aag atg tcc tgc aag gct tct gga tac acc ttc gct aac cat 153
Ala Ser Val Lys MET Ser Cys Lys Ala Ser Gly Tyr Thr Phe Ala Asn His

30 35 40 45 50

gtt att cac tgg gtg aag cag aag cca ggg cag ggc ctt gag tgg att gga 204
35 Val Ile His Trp Val Lys Gln Lys Pro Gly Gln Gly Leu Glu Trp Ile Gly

55 55 60 65

tat att tat cct tac aat gat ggt act aag tat aat gag aag ttc aag gac 255
40 Tyr Ile Tyr Pro Tyr Asn Asp Gly Thr Lys Tyr Asn Glu Lys Phe Lys Asp

70 75 80 85

aag gcc act ctg act tca gac aaa tcc tcc acc aca gcc tac atg gac ctc 306
45 Lys Ala Thr Leu Thr Ser Asp Lys Ser Ser Thr Thr Ala Tyr MET Asp Leu

90 95 100

agc agc ctg gcc tct gag gac tct gcg gtc tat tac tgt gca aga ggg ggt 357
50 Ser Ser Leu Ala Ser Glu Asp Ser Ala Val Tyr Tyr Cys Ala Arg Gly Gly

55 105 110 115

tac tat act tac gac gac tgg ggc caa ggc acc act ctc aca gtc tcg agt 408
 Tyr Tyr Thr Tyr Asp Asp Trp Gly Gln Gly Thr Thr Leu Thr Val Ser Ser
 5 120 125 130 135
 gac gtc gtg atg acc caa agt cca ctc tcc ctg cct gtc agt ctt gga gat 459
 10 Asp Val Val MET Thr Gln Ser Pro Leu Ser Leu Pro Val Ser Leu Gly Asp
 140 145 150
 caa gcc tcc atc tct tgc aga tca agt cag agc ctt gtg cac agt aat gga 510
 15 Gln Ala Ser Ile Ser Cys Arg Ser Ser Gln Ser Leu Val His Ser Asn Gly
 155 160 165 170
 20 aag acc tat tta cat tgg tac ctg cag aag cca ggc cag tct cca aaa ctc 561
 Lys Thr Tyr Leu His Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro Lys Leu
 175 180 185
 25 ctg atc tac aaa gtt tcc aac cga ttt tct ggg gtc cca gac agg ttc agt 612
 Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg Phe Ser
 190 195 200
 30 ggc agt gga tca gtg aca gat ttc aca ctc atg atc agc aga gtg gag gct 663
 Gly Ser Gly Ser Val Thr Asp Phe Thr Leu MET Ile Ser Arg Val Glu Ala
 35 205 210 215 220
 gag gat ctg gga gtt tat ttc tgc tct caa agt aca cat gtt ccg tac acg 714
 40 Glu Asp Leu Gly Val Tyr Phe Cys Ser Gln Ser Thr His Val Pro Tyr Thr
 225 230 235
 ttc gga ggg ggg acc aag ctg gaa ata aaa gac tac aaa gac gat gac gat 765
 45 Phe Gly Gly Thr Lys Leu Glu Ile Lys Asp Tyr Lys Asp Asp Asp Asp
 240 245 250 255
 50 aaa taa tga gga tcc 780
 Lys

5 <211> 45
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20 <211> 48
20 <212> DNA
25 <213> Artificial Sequence
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30 <400> 50
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35 <210> 51
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40 <212> DNA
40 <213> Artificial Sequence
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55 <210> 52
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5 <212> DNA

10 5 <213> Artificial Sequence

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15 10 <223> PCR primer

20 15 <400> 52

25 20 caagctcgag ataaaatccg gaggtgggtgg tggccaggc caattgcagc agtc 54

30 25 <210> 53

35 30 <211> 57

40 35 20 <212> DNA

45 40 <213> Artificial Sequence

50 45 <220>

55 50 <223> PCR primer

60 55 <400> 53

65 60 caagctcgag ataaaatccg gaggtgggtgg tggtggccag gtccaaattgc agcagtc 57

70 65 <210> 54

75 70 <211> 780

80 75 <212> DNA

85 80 <213> Mus

90 85 <220>

95 90 <221> CDS

100 95 <222> (1)...(768)

105 100 <223> CF2LH-0/pCOS1. MABL2-scFv<LH-0>

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115 110 atg aag ttg cct gtt agg ctg ttg gtg ctg atg ttc tgg att cct ggt tcc 51

120 115 MET Lys Leu Pro Val Arg Leu Leu Val Leu MET Phe Trp Ile Pro Gly Ser

125

5

10

15

5
agc agt gat gtt gtg atg acc caa agt cca ctc tcc ctg cct gtc agt ctt 102
Ser Ser Asp Val Val MET Thr Gln Ser Pro Leu Ser Leu Pro Val Ser Leu
20 25 30
gga gat caa gcc tcc atc tct tgc aga tca agt cag agc ctt gtg cac agt 153
Gly Asp Gln Ala Ser Ile Ser Cys Arg Ser Ser Gln Ser Leu Val His Ser
10 15 20 25
35 40 45 50
aat gga aag acc tat tta cat tgg tac ctg cag aag cca ggc cag tct cca 204
Asn Gly Lys Thr Tyr Leu His Trp Tyr Leu Gln Lys Pro Gly Gln Ser Pro
15 20 25
55 60 65
aaa ctc ctg atc tac aaa gtt tcc aac cga ttt tct ggg gtc cca gac agg 255
Lys Leu Leu Ile Tyr Lys Val Ser Asn Arg Phe Ser Gly Val Pro Asp Arg
20 25 30
70 75 80 85
ttc agt ggc agt gga tca gtg aca gat ttc aca ctc atg atc agc aga gtg 306
Phe Ser Gly Ser Gly Ser Val Thr Asp Phe Thr Leu MET Ile Ser Arg Val
25 30 35
90 95 100
gag gct gag gat ctg gga gtt tat ttc tgc tct caa agt aca cat gtt ccg 357
Glu Ala Glu Asp Leu Gly Val Tyr Phe Cys Ser Gln Ser Thr His Val Pro
30 35 40
105 110 115
tac acg ttc gga ggg ggg acc aag ctc gag ata aaa cag gtc caa ttg cag 408
Tyr Thr Phe Gly Gly Thr Lys Leu Glu Ile Lys Gln Val Gln Leu Gln
40 45 50
120 125 130 135
cag tct gga cct gaa ctg gta aag cct ggg gct tca gtg aag atg tcc tgc 459
Gln Ser Gly Pro Glu Leu Val Lys Pro Gly Ala Ser Val Lys MET Ser Cys
45 50 55
140 145 150
aag gct tct gga tac acc ttc gct aac cat gtt att cac tgg gtg aag cag 510
Lys Ala Ser Gly Tyr Thr Phe Ala Asn His Val Ile His Trp Val Lys Gln
50 55 60
155 160 165 170
aag cca ggg cag ggc ctt gag tgg att gga tat att tat cct tac aat gat 561

Lys Pro Gly Gln Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Pro Tyr Asn Asp
 5 175 180 185
 ggt act aag tat aat gag aag ttc aag gac aag gcc act ctg act tca gac 612
 Gly Thr Lys Tyr Asn Glu Lys Phe Lys Asp Lys Ala Thr Leu Thr Ser Asp
 10 190 195 200
 aaa tcc tcc acc aca gcc tac atg gac ctc agc agc ctg gcc tct gag gac 663
 Lys Ser Ser Thr Thr Ala Tyr MET Asp Leu Ser Ser Leu Ala Ser Glu Asp
 15 205 210 215 220
 tct gcg gtc tat tac tgt gca aga ggg ggt tac tat act tac gac gac tgg 714
 20 Ser Ala Val Tyr Tyr Cys Ala Arg Gly Gly Tyr Tyr Thr Tyr Asp Asp Trp
 225 230 235
 ggc caa ggc acc act ctc aca gtc tcc tca gac tac aaa gac gat gac gat 765
 25 Gly Gln Gly Thr Thr Leu Thr Val Ser Ser Asp Tyr Lys Asp Asp Asp Asp
 240 245 250 255
 30 aaa taa tga gga tcc 780
 Lys

35 <210> 55
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 40 <212> DNA
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 <220>
 45 <221> CDS
 <222> (1)...(351)
 50 <223> 12B5HV. 1-351 peptide
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 55 Gln Val Gln Leu Val Gln Ser Gly Gly Leu Val Arg Pro Gly Gly

	1	5	10	15													
5	tcc	ctg	agt	ctc	tcc	tgt	gca	gtc	tct	gga	atc	acc	ctc	agg	acc	tac	96
	Ser	Leu	Ser	Leu	Ser	Cys	Ala	Val	Ser	Gly	Ile	Thr	Leu	Arg	Thr	Tyr	
10																	144
	ggc	atg	cac	tgg	gtc	cgc	cag	gct	cca	ggc	aag	ggg	ctg	gag	tgg	gtg	
	Gly	Met	His	Trp	Val	Arg	Gln	Ala	Pro	Gly	Lys	Gly	Leu	Glu	Trp	Val	
15																	192
	gca	ggt	ata	tcc	ttt	gac	gga	aga	agt	gaa	tac	tat	gca	gac	tcc	gtg	
	Ala	Gly	Ile	Ser	Phe	Asp	Gly	Arg	Ser	Glu	Tyr	Tyr	Ala	Asp	Ser	Val	
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	cag	ggc	cga	ttc	acc	atc	tcc	aga	gac	agt	tcc	aag	aac	acc	ctg	tat	
	Gln	Gly	Arg	Phe	Thr	Ile	Ser	Arg	Asp	Ser	Ser	Lys	Asn	Thr	Leu	Tyr	
25																	288
	65																
	ctg	caa	atg	aac	agc	ctg	aga	gcc	gag	gac	acg	gct	gtg	tat	tac	tgt	
30	Leu	Gln	Met	Asn	Ser	Leu	Arg	Ala	Glu	Asp	Thr	Ala	Val	Tyr	Tyr	Cys	
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35	gcg	aga	gga	gca	cat	tat	ggt	ttc	gat	atc	tgg	ggc	caa	ggg	aca	atg	
	Ala	Arg	Gly	Ala	His	Tyr	Gly	Phe	Asp	Ile	Trp	Gly	Gln	Gly	Thr	Met	
																	351
40																	
	100																
	gtc	acc	gtc	tcg	agt												
45	Val	Thr	Val	Ser	Ser												
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50	<210>	56															
	<211>	57															
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55	<213>	Human															
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5 <221> CDS

5 <222> (1)... (57)

5 <223> reader sequence

10 <400> 56

10 atg gag ttt ggg ctg agc tgg gtt ttc ctc gtt gct ctt tta aga ggt 48

Met Glu Phe Gly Leu Ser Trp Val Phe Leu Val Ala Leu Leu Arg Gly

15 5

10

15

15 gtc cag tgt

57

20 Val Gln Cys

25 <210> 57

25 <211> 115

25 <212> DNA

30 <213> Artificial Sequence

30 <220>

35 <223> 12B5VH-1

35 <400> 57

40 atggagtttggctgagctggttttcctcgttgctctttaagagggtgtccagtgtcag 60

40 gtgcagctgg tgcagtctgg gggaggcttggccggcccg ggggtccct gagtc 115

45 <210> 58

45 <211> 115

45 <212> DNA

50 <213> Artificial Sequence

50 <220>

55 <223> 12B5VH-2

55 <400> 58

aaggatatac ctgccaccca ctccagcccc ttgcctggag cctggcggac ccagtgcattg 60

ccgttaggtcc tgagggtgat tccagagact gcacaggaga gactcaggga ccccc 115

5 <210> 59

10 <211> 115

<212> DNA

15 <213> Artificial Sequence

<220>

<223> 12B5VH-3

20 <400> 59

ggcaggatata tccttgacg gaagaagtga atactatgca gactccgtgc agggccgatt 60

caccatctcc agagacagtt ccaagaacac cctgtatctg caaatgaaca gcctg 115

25 <210> 60

30 <211> 108

<212> DNA

35 <213> Artificial Sequence

<220>

<223> 12B5VH-4

40 <400> 60

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cgcacagtaa tacacagccg tgtcctcgcc ttcaggctg ttcatttg 108

45 <210> 61

50 <211> 32

<212> DNA

55 <213> Artificial Sequence

<220>

5 <223> 12B5VH-S, PCR primer

5 <400> 61

ttcaagcttc caccatggag tttgggctga gc 32

10 <210> 62

<211> 34

15 <212> DNA

<213> Artificial Sequence

<220>

20 <223> 12B5VH-A, PCR primer

<400> 62

25 ttgggatcca ctcaccactc gagacggtga ccat 34

<210> 63

30 <211> 588

<212> DNA

35 <213> Human

<220>

<221> CDS

40 <222> (236)...(558)

<223> 1-235;intron, 236-558;Human IgG constant region (partial)

<400> 63

45 gaattcgtga gtggatccca agcttagcttt ctggggcagg ccaggcctga ccttggcttt 60

ggggcaggga gggggctaag gtgagggcagg tggcgccagc caggtgcaca cccaatgccc 120

50 atgagcccaag acactggacg ctgaacctcg cggacagtta agaacccagg ggcctctgcg 180

ccctgggccc agctctgtcc cacaccgcgg tcacatggca caacctctct tgca gcc 237

Ala

5	tcc acc aag ggc cca tcg gtc ttc ccc ctg gca ccc tcc tcc aag agc	285
	Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala Pro Ser Ser Lys Ser	
	5 10 15	
10	acc tct ggg ggc aca gcg gcc ctg ggc tgc ctg gtc aag gac tac ttc	333
	Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu Val Lys Asp Tyr Phe	
	20 25 30	
15	ccc gaa ccg gtg acg gtg tcg tgg aac tca ggc gcc ctg acc agc ggc	381
	Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly Ala Leu Thr Ser Gly	
	35 40 45	
20	gtg cac acc ttc ccg gct gtc cta cag tcc tca gga ctc tac tcc ctc	429
	Val His Thr Phe Pro Ala Val Leu Gln Ser Ser Gly Leu Tyr Ser Leu	
	50 55 60 65	
25	agc agc gtg gtg acc gtg ccc tcc agc agc ttg ggc acc cag acc tac	477
	Ser Ser Val Val Thr Val Pro Ser Ser Leu Gly Thr Gln Thr Tyr	
	70 75 80	
30	atc tgc aac gtg aat cac aag ccc agc aac acc aag gtg gac aag aaa	525
	Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr Lys Val Asp Lys Lys	
	35 85 90 95	
	gtt gag ccc aaa tct tgt gac aaa act cac aca	558
40	Val Glu Pro Lys Ser Cys Asp Lys Thr His Thr	
	100 105	
45	<210> 64	
	<211> 27	
50	<212> DNA	
	<213> Artificial Sequence	
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55	<223> G1CH1-S, PCR primer	

5 <400> 64

tgagaattcg tgagtggatc ccaagct 27

10 <210> 65

<211> 60

<212> DNA

15 <213> Artificial Sequence

<220>

20 <223> G1CH1-A, PCR primer

<400> 65

aaaagatctt tatcatgtgt gagtttgtc acaagatttggctcaactt tcttgtccac 60

25 <210> 66

<211> 432

30 <212> DNA

<213> Human

35 <220>

<221> CDS

<222> (12)...(419)

40 <223> HEF-12B5H-g gamma. 12-419 peptide

<400> 66

45 aagcttccac c atg gag ttt ggg ctg agc tgg gtt ttc ctc gtt gct ctt 50

Met Glu Phe Gly Leu Ser Trp Val Phe Leu Val Ala Leu

1 5 10

50 tta aga ggt gtc cag tgt cag gtg cag ctg gtg cag tct ggg gga ggc 98

Leu Arg Gly Val Gln Cys Gln Val Gln Leu Val Gln Ser Gly Gly

15 20 25

55 ttg gtc cgg ccc ggg tcc ctg agt ctc tcc tgt gca gtc tct gga 146

Leu Val Arg Pro Gly Gly Ser Leu Ser Leu Ser Cys Ala Val Ser Gly
 5 30 35 40 45
 atc acc ctc agg acc tac ggc atg cac tgg gtc cgc cag gct cca ggc 194
 Ile Thr Leu Arg Thr Tyr Gly Met His Trp Val Arg Gln Ala Pro Gly
 10 50 55 60
 aag ggg ctg gag tgg gtg gca ggt ata tcc ttt gac gga aga agt gaa 242
 Lys Gly Leu Glu Trp Val Ala Gly Ile Ser Phe Asp Gly Arg Ser Glu
 15 65 70 75
 tac tat gca gac tcc gtg cag ggc cga ttc acc atc tcc aga gac agt 290
 20 Tyr Tyr Ala Asp Ser Val Gln Gly Arg Phe Thr Ile Ser Arg Asp Ser
 80 85 90
 tcc aag aac acc ctg tat ctg caa atg aac agc ctg aga gcc gag gac 338
 25 Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp
 95 100 105
 acg gct gtg tat tac tgt gcg aga gga gca cat tat ggt ttc gat atc 386
 Thr Ala Val Tyr Tyr Cys Ala Arg Gly Ala His Tyr Gly Phe Asp Ile
 30 110 115 120 125
 tgg ggc caa ggg aca atg gtc acc gtc tcg agt ggtgagtggta tcc 432
 Trp Gly Gln Gly Thr Met Val Thr Val Ser Ser
 35 130 135

<210> 67

<211> 321

<212> DNA

<213> Human

<220>

<221> CDS

<222> (1)...(321)

5 <223> 12B5LV. 1-321 peptide

67

gac atc cag atg acc cag tct cct tcc acc ctg tct gca tct att gga 48

Asp Ile Gln Met Thr Gln Ser Pro Ser Thr Leu Ser Ala Ser Ile Gly

10 1 5 10 15

gac aga gtc acc atc acc tgc cgg gcc agc gag ggt att tat cac tgg 96

Asp Arg Val Thr Ile Thr Cys Arg Ala Ser Glu Gly Ile Tyr His Trp

15 20 25 30

ttg gcc tgg tat cag cag aag cca ggg aaa gcc cct aaa ctc ctg atc 144

Leu Ala Trp Tyr Gln Gln Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile

20 35 40 45

tat aag gcc tct agt tta gcc agt ggg gcc cca tca agg ttc agc ggc 192

Tyr Lys Ala Ser Ser Leu Ala Ser Gly Ala Pro Ser Arg Phe Ser Gly

25 50 55 60

agt gga tct ggg aca gat ttc act ctc acc atc agc agc ctg cag cct 240

Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro

30 65 70 75 80

gat gat ttt gca act tat tac tgc caa caa tat agt aat tat ccg ctc 288

Asp Asp Phe Ala Thr Tyr Tyr Cys Gln Gln Tyr Ser Asn Tyr Pro Leu

35 85 90 95

act ttc ggc gga ggg acc aag ctg gag atc aaa 321

40 Thr Phe Gly Gly Thr Lys Leu Glu Ile Lys

45 100 105

50 <210> 68

<211> 66

55 <212> DNA

<213> Human

5 <220>

10 <221> CDS

15 <222> (1)...(66)

20 <223> reader sequence

25 <400> 68

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MET Asp MET Arg Val Pro Ala Gln Leu Leu Gly Leu Leu Leu Trp

30 5

10

15

35 ctc cca ggt gcc aaa tgt

66

40 Leu Pro Gly Ala Lys Cys

45 20

50 <210> 69

55 <211> 110

60 <212> DNA

65 <213> Artificial Sequence

70 <220>

75 <223> 12B5VL-1

80 <400> 69

85 atggacatga gggccccgc tcagtcctg gggctcctgc tgctctggct cccaggtgcc 60

aaatgtgaca tccagatgac ccagtctcct tccaccctgt ctgcatctat 110

90 <210> 70

95 <211> 110

100 <212> DNA

105 <213> Artificial Sequence

110 <220>

115 <223> 12B5VL-2

5 <400> 70

ggagtttagg ggcttccct ggcttctgct gataccaggc caaccagtga taaataccct 60
cgctggcccg gcaggtgatg gtgactctgt ctccaataga tgcagacagg 110

10 <210> 71

<211> 110

15 <212> DNA

<213> Artificial Sequence

<220>

20 <223> 12B5VL-3

<400> 71

aagcccctaa actcctgatc tataaggcct ctagtttagc cagtggggcc ccatcaaggt 60
tcagcggcag tggatctggg acagattca ctctcaccat cagcagcctg 110

30 <210> 72

<211> 103

35 <212> DNA

<213> Artificial Sequence

<220>

40 <223> 12B5VL-4

<400> 72

tttgatctcc agcttggtcc ctccggcggaa agtgagcgga taattactat attgttggca 60
gtaataagtt gcaaaatcat caggctgcag gctgctgatg gtg 103

50 <210> 73

<211> 32

55 <212> DNA

<213> Artificial Sequence

5 <220>

5 <223> 12B5VL-S; PCR primer

10 <400> 73

10 ttcaagcttc caccatggac atgagggtcc cc 32

15 <210> 74

15 <211> 35

15 <212> DNA

20 <213> Artificial Sequence

20 <220>

20 <223> 12B5VL-A, PCR primer

25 <400> 74

25 tcttaggatcc actcacgtt gatctccagc ttgg 35

30 <210> 75

30 <211> 415

35 <212> DNA

35 <213> Human

40 <220>

40 <221> CDS

45 <222> (12)...(398)

45 <223> HEF-12B5H-g kappa. 12-398 peptide

50 <400> 75

50 aagcttccac c atg gac atg agg gtc ccc gct cag ctc ctg ggg ctc ctg 50

50 Met Asp Met Arg Val Pro Ala Gln Leu Leu Gly Leu Leu

1

5

10

55 ctg ctc tgg ctc cca ggt gcc aaa tgt gac atc cag atg acc cag tct 98

55 Leu Leu Trp Leu Pro Gly Ala Lys Cys Asp Ile Gln Met Thr Gln Ser

	15	20	25	
5	cct tcc acc ctg tct gca tct att gga gac aga gtc acc atc acc tgc			146
	Pro Ser Thr Leu Ser Ala Ser Ile Gly Asp Arg Val Thr Ile Thr Cys			
	30	35	40	45
10	cgg gcc agc gag ggt att tat cac tgg ttg gcc tgg tat cag cag aag			194
	Arg Ala Ser Glu Gly Ile Tyr His Trp Leu Ala Trp Tyr Gln Gln Lys			
15	50	55	60	
	cca ggg aaa gcc cct aaa ctc ctg atc tat aag gcc tct agt tta gcc			242
	Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Lys Ala Ser Ser Leu Ala			
20	65	70	75	
	agt ggg gcc cca tca agg ttc agc ggc agt gga tct ggg aca gat ttc			290
	Ser Gly Ala Pro Ser Arg Phe Ser Gly Ser Gly Thr Asp Phe			
25	80	85	90	
	act ctc acc atc agc agc ctg cag cct gat gat ttt gca act tat tac			338
	Thr Leu Thr Ile Ser Ser Leu Gln Pro Asp Asp Phe Ala Thr Tyr Tyr			
30	95	100	105	
	tgc caa caa tat agt aat tat ccg ctc act ttc ggc gga ggg acc aag			386
35	Cys Gln Gln Tyr Ser Asn Tyr Pro Leu Thr Phe Gly Gly Thr Lys			
	110	115	120	125
40	ctg gag atc aaa cgtgagtgga tcctaga			415
	Leu Glu Ile Lys			
45	<210> 76			
	<211> 24			
50	<212> DNA			
	<213> Artificial Sequence			
	<220>			
55	<223> FLAG tag sequence			

5 <400> 76
gac tac aag gat gac gac gat aag 24
Asp Tyr Lys Asp Asp Asp Asp Lys

5

10

<210> 77
<211> 31
<212> DNA
<213> Artificial Sequence

20

<220>
<223> 12B5-S, PCR primer
<400> 77

25

atagaattcc accatggagt ttgggctgag c 31

30

<210> 78
<211> 24
<212> DNA
<213> Artificial Sequence

35

<220>
<223> HuVHJ3, PCR primer
<400> 78

40

tgaagagacg gtgaccattg tccc 24

45

<210> 79
<211> 28
<212> DNA
<213> Artificial Sequence
<220>

55

5

<223> RhuJH3, PCR primer
<400> 79
ggacaatggt caccgtctct tcaggtgg 28

10

<210> 80

15

<211> 32
<212> DNA
<213> Artificial Sequence

20

<220>
<223> RhuVK1, PCR primer
<400> 80

25

ggagactggg tcatctggat gtccgatccg cc 32

30

<210> 81
<211> 23
<212> DNA
<213> Artificial Sequence

35

<220>
<223> HuVK1.2, PCR primer
<400> 81
gacatccaga tgacctcagtc tcc 23

45

<210> 82
<211> 59
<212> DNA
<213> Artificial Sequence
<220>
<223> 12B5F-A, PCR primer

<400> 82

5 attgcggccg cttatcaatt atcggtgtca tcctttagt ctgtatctc cagcttggt 59

<210> 83

10 <211> 45

<212> DNA

15 <213> Artificial Sequence

<220>

<223> Linker amino acid sequence and nucleotide sequence

20 <400> 83

ggt ggt ggt ggt tcg ggt ggt ggt tcg ggt ggt ggc gga tcg 45

25 Gly Gly Gly Gly Ser Gly Gly Gly Ser Gly Gly Gly Ser

5

10

15

30 <210> 84

<211> 823

35 <212> DNA

<213> Human

<220>

40 <221> CDS

<222> (12)...(809)

45 <223> sc12B5, Single chain Fv

<400> 84

aagcttccac c atg gag ttt ggg ctg agc tgg gtt ttc ctc gtt gct ctt 50

50 Met Glu Phe Gly Leu Ser Trp Val Phe Leu Val Ala Leu

1

5

10

tta aga ggt gtc cag tgt cag gtg cag ctg gtg cag tct ggg gga ggc 98

55 Leu Arg Gly Val Gln Cys Gln Val Gln Leu Val Gln Ser Gly Gly

	15	20	25	
5	ttg gtc cgg ccc ggg ggg tcc ctg agt ctc tcc tgt gca gtc tct gga			146
	Leu Val Arg Pro Gly Gly Ser Leu Ser Leu Ser Cys Ala Val Ser Gly			
	30	35	40	45
10	atc acc ctc agg acc tac ggc atg cac tgg gtc cgc cag gct cca ggc			194
	Ile Thr Leu Arg Thr Tyr Gly Met His Trp Val Arg Gln Ala Pro Gly			
15	50	55	60	
	aag ggg ctg gag tgg gtg gca ggt ata tcc ttt gac gga aga agt gaa			242
	Lys Gly Leu Glu Trp Val Ala Gly Ile Ser Phe Asp Gly Arg Ser Glu			
20	65	70	75	
	tac tat gca gac tcc gtg cag ggc cga ttc acc atc tcc aga gac agt			290
25	Tyr Tyr Ala Asp Ser Val Gln Gly Arg Phe Thr Ile Ser Arg Asp Ser			
	80	85	90	
	tcc aag aac acc ctg tat ctg caa atg aac agc ctg aga gcc gag gac			338
30	Ser Lys Asn Thr Leu Tyr Leu Gln Met Asn Ser Leu Arg Ala Glu Asp			
	95	100	105	
35	acg gct gtg tat tac tgt gcg aga gga gca cat tat ggt ttc gat atc			386
	Thr Ala Val Tyr Tyr Cys Ala Arg Gly Ala His Tyr Gly Phe Asp Ile			
	110	115	120	125
40	tgg ggc caa ggg aca atg gtc acc gtc tcg agt ggt ggt ggt tcg			434
	Trp Gly Gln Gly Thr Met Val Thr Val Ser Ser Gly Gly Gly Ser			
	130	135	140	
45	ggt ggt ggt tcg ggt ggt ggc gga tcg gac atc cag atg acc cag			482
	Gly Gly Gly Ser Gly Gly Ser Asp Ile Gln Met Thr Gln			
50	145	150	155	
	tct cct tcc acc ctg tct gca tct att gga gac aga gtc acc atc acc			530
	Ser Pro Ser Thr Leu Ser Ala Ser Ile Gly Asp Arg Val Thr Ile Thr			
55	160	165	170	

tgc cgg gcc agc gag ggt att tat cac tgg ttg gcc tgg tat cag cag 578
 5 Cys Arg Ala Ser Glu Gly Ile Tyr His Trp Leu Ala Trp Tyr Gln Gln
 175 180 185
 aag cca ggg aaa gcc cct aaa ctc ctg atc tat aag gcc tct agt tta 626
 10 Lys Pro Gly Lys Ala Pro Lys Leu Leu Ile Tyr Lys Ala Ser Ser Leu
 190 195 200 205
 15 gcc agt ggg gcc cca tca agg ttc agc ggc agt gga tct ggg aca gat 674
 Ala Ser Gly Ala Pro Ser Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp
 210 215 220
 20 ttc act ctc acc atc agc agc ctg cag cct gat gat ttt gca act tat 722
 Phe Thr Leu Thr Ile Ser Ser Leu Gln Pro Asp Asp Phe Ala Thr Tyr
 225 230 235
 25 TAC TGC CAA CAA TAT AGT AAT TAT CCG CTC ACT TTC GGC GGA GGG ACC 770
 Tyr Cys Gln Gln Tyr Ser Asn Tyr Pro Leu Thr Phe Gly Gly Thr
 30 240 245 250
 aag ctg gag atc aaa gac tac aag gat gac gac gat aag tgataaggcg 820
 Lys Leu Glu Ile Lys Asp Tyr Lys Asp Asp Asp Lys
 35 255 260 265
 cgcc 823
 40 <210> 85
 <211> 114
 45 <212> PRT
 <213> Human
 50 <400> 85
 Gln Val Gln Leu Gln Gln Ser Gly Pro Gly Leu Val Lys Pro Ser Glu
 55 1 5 10 15

Thr Leu Ser Leu Thr Cys Thr Val Ser Gly Asp Ser Ile Ser Ser Tyr

20 25 30

Tyr Trp Ser Trp Ile Arg Gln Pro Pro Gly Lys Gly Leu Glu Trp Ile

35 40 45

Gly Tyr Ile Tyr Tyr Ser Gly Ser Thr Asn Tyr Asn Pro Ser Leu Lys

50 55 60

Ser Arg Val Thr Ile Ser Val Asp Thr Ser Lys Ser Gln Phe Ser Leu

15 65 70 75 80

Lys Leu Ser Ser Val Thr Ala Ala Asp Thr Ala Val Tyr Tyr Cys Ala

20 85 90 95

Arg Gly Arg Tyr Phe Asp Val Trp Gly Arg Gly Thr Met Val Thr Val

100 105 110

25 Ser Ser

30 <210> 86

<211> 342

<212> DNA

35 <213> Human

40 <400> 86

caggtgcagc tgcagcagtc gggcccagga ctggtaagc cttcgagac cctgtccctc 60

acctgcactg tctctggta ctccatca agttactact ggagctggat tcggcagccc 120

ccagggagg gactggatg gattgggtat atctattaca gtgggagcac caactacaac 180

ccctccctca agagtgcagt caccatatca gtagacacgt ccaagagcca gttctccctg 240

aagctgagct ctgtgaccgc cgcaacacg gccgtgtatt actgtgcgag agggcggtac 300

ttcgatgtct gggccgtgg caccatggtc actgtctcct ca 342

55 <210> 87

<211> 57

<212> DNA

<213> Human

<220>

<221> CDS

<222> (1)...(57)

<223> reader sequence

<308> GenBank No. AF062252

<400> 87

atg aaa cat ctg tgg ttc ttc ctt ctc ctg gtg gca gct ccc aga tgg 48

Met Lys His Leu Trp Phe Phe Leu Leu Leu Val Ala Ala Pro Arg Trp

1

5

10

15

gtc ctg tcc

57

Val Leu Ser

<210> 88

<211> 110

<212> DNA

<213> Artificial Sequence

<220>

<223> 12E10VH1

<400> 88

atgaaaacatc tgtggttctt ctttccttg gtggcagctc ccagatgggt cctgtcccag 60

gtgcagctgc agcagtctggg cccaggactg gtgaagcctt cggagaccct 110

<210> 89

<211> 110

<212> DNA

5 <213> Artificial Sequence

10 <220>
15 <223> 12E10VH2
20 <400> 89
25 acccaaatcca ctccagtc cc ttcctgggg gctgccgaat ccagctccag tagtaactac 60
30 tgatggagtc accagagaca gtgcaggta gggacagggt ctccgaaggc 110
35 <210> 90
40 <211> 110
45 <212> DNA
50 <213> Artificial Sequence
55 <220>
60 <223> 12E10VH3
65 <400> 90
70 tggagtggat tggtatatac tattacagtg ggagcaccaa ctacaacccc tccctcaaga 60
75 gtcgagtcac catatcagta gacacgtcca agagccagtt ctccctgaag 110
80 <210> 91
85 <211> 114
90 <212> DNA
95 <213> Artificial Sequence
100 <220>
105 <223> 12E10VH4
110 <400> 91
115 tgaggagaca gtgaccatgg tgccacggcc ccagacatcg aagtaccgcc ctctcgacaca 60
120 gtaatacacg gccgtgtctg cggcggtcac agagctcagc ttcaaggaga actg 114
125 <210> 92

5 <211> 32

<212> DNA

10 <213> Artificial Sequence

<220>

15 <223> 12E10VHS, PCR primer

<400> 92

ttcaagcttc caccatgaaa catctgtggc tc 32

20 <210> 93

<211> 34

<212> DNA

25 <213> Artificial Sequence

<220>

<223> 12E10VHA, PCR primer

30 <400> 93

ttgggatcca ctcacctgag gagacagtga ccat 34

35 <210> 94

<211> 426

40 <212> DNA

<213> Mus

<220>

45 <221> CDS

<222> (12)...(417)

50 <223> 12E10H, H chain V region

<400> 94

aagcttccac c atg aaa cat ctg tgg ttc ttc ctt ctc ctg gtg gca gct 50

55 Met Lys His Leu Trp Phe Phe Leu Leu Leu Val Ala Ala

	1	5	10
5	ccc aga tgg gtc ctg tcc cag gtg cag ctg cag cag tcg ggc cca gga		98
	Pro Arg Trp Val Leu Ser Gln Val Gln Leu Gln Gln Ser Gly Pro Gly		
	15	20	25
10	ctg gtg aag cct tcg gag acc ctg tcc ctc acc tgc act gtc tct ggt		146
	Leu Val Lys Pro Ser Glu Thr Leu Ser Leu Thr Cys Thr Val Ser Gly		
15	30	35	40
	gac tcc atc agt agt tac tac tgg agc tgg att cgg cag ccc cca ggg		194
	Asp Ser Ile Ser Ser Tyr Tyr Trp Ser Trp Ile Arg Gln Pro Pro Gly		
20	50	55	60
	aag gga ctg gag tgg att ggg tat atc tat tac agt ggg agc acc aac		242
	Lys Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Tyr Ser Gly Ser Thr Asn		
25	65	70	75
	tac aac ccc tcc ctc aag agt cga gtc acc ata tca gta gac acg tcc		290
30	Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Ile Ser Val Asp Thr Ser		
	80	85	90
	aag agc cag ttc tcc ctg aag ctg agc tct gtg acc gcc gca gac acg		338
35	Lys Ser Gln Phe Ser Leu Lys Leu Ser Ser Val Thr Ala Ala Asp Thr		
	95	100	105
40	gcc gtg tat tac tgt gcg aga ggg cgg tac ttc gat gtc tgg ggc cgt		386
	Ala Val Tyr Tyr Cys Ala Arg Gly Arg Tyr Phe Asp Val Trp Gly Arg		
	110	115	120
45	125		
	ggc acc atg gtc act gtc tcc tca ggtgagtggaa tcccaa		426
	Gly Thr Met Val Thr Val Ser Ser		
50	130		
	<210> 95		
55	<211> 110		

<212> PRT

5

<213> Mus

<400> 95

10 Ser Tyr Val Leu Thr Gln Pro Pro Ser Val Ser Gly Ser Pro Gly Gln

1 5 10 15

15 Ser Ile Thr Ile Ser Cys Thr Gly Thr Ser Ser Asp Val Gly Gly Tyr

20 25 30

20 Asn Tyr Val Ser Trp Tyr Gln Gln His Pro Gly Lys Ala Pro Lys Leu

25 35 40 45

Met Ile Tyr Glu Gly Ser Lys Arg Pro Ser Gly Val Ser Asn Arg Phe

25 50 55 60

25 Ser Gly Ser Lys Ser Gly Asn Thr Ala Ser Leu Thr Ile Ser Gly Leu

30 65 70 75 80

30 Gln Ala Glu Asp Glu Ala Asp Tyr Tyr Cys Ser Ser Tyr Thr Thr Arg

35 85 90 95

35 Ser Thr Arg Val Phe Gly Gly Thr Lys Leu Thr Val Leu

40 100 105 110

40 <210> 96

45 <211> 330

<212> DNA

45 <213> Mus

50 <400> 96

50 tcctatgtgc tgactcagcc accctcggtg tcagggtctc ctggacagtc gatcaccatc 60

55 tcctgcactg gaaccagcag tgacgttgt gttataact atgtctcctg gtaccaacag 120

cacccaggca aagcccccaa actcatgatt tatgagggca gtaaacggcc ctcaggggtt 180

tctaatcgct tctctggctc caagtcgtggc aacacggcct ccctgaccat ctctgggctc 240
 caggctgagg acgaggctga ttattactgc agctcatata caaccagaag cactcgggtg 300
 ttccggcggag ggaccaagct gaccgtccta 330

 10 <210> 97
 <211> 57
 <212> DNA
 15 <213> Human
 <220>
 20 <221> CDS
 <222> (1)...(57)
 <223> reader sequence
 25 <310>
 <400> 97
 30 atg gcc tgg acc gtt ctc ctc ctc ggc ctc ctc tct cac tgc aca ggc 48
 Met Ala Trp Thr Val Leu Leu Leu Gly Leu Leu Ser His Cys Thr Gly
 1 5 10 15
 35 tct gtg acc 57
 Ser Val Thr

 40 <210> 98
 <211> 110
 45 <212> DNA
 <213> Artificial Sequence
 50 <220>
 <223> 12E10VL1, PCR primer
 <400> 98
 55 atggcctgga ccgttctcct cctccgcctc ctctctcact gcacaggctc tgtgacacctc 60

5 tatgtgctga ctcagccacc ctgggtgtca gggtctcctg gacagtgcat 110

10 <210> 99
 <211> 62
 <212> DNA
 <213> Artificial Sequence
 <220>
15 <223> 12E10VL2, PCR primer
 <400> 99

20 tcatgagttt gggggctttg cctgggtgct gttggtagcca ggagacatag ttataaccac 60
 caacgtcact gctggttcca gtgcaggaga tggtgatcga ctgtccagga 110

25 <210> 100
 <211> 110
 <212> DNA
 <213> Artificial Sequence
 <220>
30 <223> 12E10VL3, PCR primer
 <400> 100

35 cccccaaact catgatttat gagggcagta aacggccctc aggggttct aatcgcttct 60
 ctggctccaa gtctggcaac acggcctccc tgaccatctc tgggctccag 110

40 <210> 101
 <211> 102
 <212> DNA
 <213> Artificial Sequence
 <220>
45 <223> 12E10VL4, PCR primer

50
55

5 <400> 101
taggacggtc agcttggtcc ctccgcccga a caccggatg cttctggttg tatatgagct 60
gcagtaataa tcagcctcg t cctcagccctg gagcccagag at 102

10 <210> 102
<211> 31
<212> DNA
15 <213> Artificial Sequence
<220>
20 <223> 12E10VLS, PCR primer
<400> 102
atcaaggcttc caccatggcc tggaccgttc t 31
25

<210> 103
30 <211> 36
<212> DNA
<213> Artificial Sequence
35 <220>
<223> 12E10VLA, PCR primer
40 <400> 103
ctaggatccg ggctgaccta ggacggtcag ctgggt 36

45 <210> 104
<211> 387
50 <212> DNA
<213> Mus
<220>
55 <221> CDS

<222> (1)... (387)

<223> 12E10L, L chain V region

<310>

<400> 104

atg gcc tgg acc gtt ctc ctc ctc ggc ctc ctc tct cac tgc aca ggc 48

Met Ala Trp Thr Val Leu Leu Leu Gly Leu Leu Ser His Cys Thr Gly

1 5 10 15

tct gtg acc tcc tat gtg ctg act cag cca ccc tcg gtg tca ggg tct 96

Ser Val Thr Ser Tyr Val Leu Thr Gln Pro Pro Ser Val Ser Gly Ser

20 25 30

cct gga cag tcg atc acc atc tcc tgc act gga acc agc agt gac gtt 144

Pro Gly Gln Ser Ile Thr Ile Ser Cys Thr Gly Thr Ser Ser Asp Val

25 35 40 45

ggg ggt tat aac tat gtc tcc tgg tac caa cag cac cca ggc aaa gcc 192

30 Gly Gly Tyr Asn Tyr Val Ser Trp Tyr Gln Gln His Pro Gly Lys Ala

50 55 60

ccc aaa ctc atg att tat gag ggc agt aaa cgg ccc tca ggg gtt tct 240

35 Pro Lys Leu Met Ile Tyr Glu Gly Ser Lys Arg Pro Ser Gly Val Ser

65 70 75 80

40 aat cgc ttc tct ggc tcc aag tct ggc aac acg gcc tcc ctg acc atc 288

Asn Arg Phe Ser Gly Ser Lys Ser Gly Asn Thr Ala Ser Leu Thr Ile

85 90 95

45 tct ggg ctc cag gct gag gac gag gct gat tat tac tgc agc tca tat 336

Ser Gly Leu Gln Ala Glu Asp Glu Ala Asp Tyr Tyr Cys Ser Ser Tyr

50 100 105 110

Aca acc aga agc act cgg gtg ttc ggc gga ggg acc aag ctg acc gtc 384

55 Thr Thr Arg Ser Thr Arg Val Phe Gly Gly Thr Lys Leu Thr Val

115 120 125

387

5 cta

Leu

5

<210> 105

10

<211> 24

<212> DNA

<213> Artificial Sequence

15

<220>

<221> CDS

20

<222> (1)...(24)

<223> FLAG, reader sequence

<400> 105

25

gac tac aag gat gac gac gat aag 24

Asp Tyr Lys Asp Asp Asp Asp Lys

30

<210> 106

<211> 30

35

<212> DNA

<213> Artificial Sequence

40

<220>

<223> 12E10S, PCR primer

<400> 106

45

tatgaattcc accatgaaac atctgtggtt 30

50

<210> 107

<211> 38

<212> DNA

55

<213> Artificial Sequence

5 <220>

5 <223> DB2, PCR primer

10 <400> 107

10 taggagctac cgcctccacc tgaggagaca gtgaccat 38

15 <210> 108

15 <211> 44

15 <212> DNA

20 <213> Artificial Sequence

20 <220>

25 <223> DB1, PCR primer

25 <400> 108

25 gtctcctcag gtggaggcgg tagtcctat gtgctgactc agcc 44

30 <210> 109

30 <211> 59

30 <212> DNA

35 <213> Artificial Sequence

35 <220>

40 <223> 12E10FA, PCR primer

40 <400> 109

45 attgcggccg cttatcaatt atcgctgtca tcctttagt ctaggacggt cagcttggt 59

50 <210> 110

50 <211> 792

50 <212> DNA

55 <213> Artificial Sequence

55 <220>

<221> CDS

<222> (11)...(778)

<223> 12E10, Single chain Fv

<400> 110

gaattccacc atg aaa cat ctg tgg ttc ttc ctt ctc ctc gtg gca gct 49

Met Lys His Leu Trp Phe Phe Leu Leu Leu Val Ala Ala

1 5 10

ccc aga tgg gtc ctg tcc cag gtg cag ctc cag cag tcg ggc cca gga 97

Pro Arg Trp Val Leu Ser Gln Val Gln Leu Gln Gln Ser Gly Pro Gly

15 20 25

ctg gtg aag cct tcg gag acc ctg tcc ctc acc tgc act gtc tct ggt 145

Leu Val Lys Pro Ser Glu Thr Leu Ser Leu Thr Cys Thr Val Ser Gly

25 30 35 40 45

gac tcc atc agt agt tac tac tgg agc tgg att cgg cag ccc cca ggg 193

Asp Ser Ile Ser Ser Tyr Tyr Trp Ser Trp Ile Arg Gln Pro Pro Gly

50 55 60

aag gga ctg gag tgg att ggg tat atc tat tac agt ggg agc acc aac 241

35 Lys Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Tyr Ser Gly Ser Thr Asn

65 70 75

40 tac aac ccc tcc ctc aag agt cga gtc acc ata tca gta gac acg tcc 289

Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Ile Ser Val Asp Thr Ser

80 85 90

45 aag agc cag ttc tcc ctg aag ctg agc tct gtg acc gcc gca gac acg 337

Lys Ser Gln Phe Ser Leu Lys Leu Ser Ser Val Thr Ala Ala Asp Thr

50 95 100 105

gcc gtg tat tac tgt gcg aga ggg cgg tac ttc gat gtc tgg ggc cgt 385

Ala Val Tyr Tyr Cys Ala Arg Gly Arg Tyr Phe Asp Val Trp Gly Arg

55 110 115 120 125

ggc acc atg gtc act gtc tcc tca ggt gga ggc ggt agc tcc tat gtg 433
 Gly Thr Met Val Thr Val Ser Ser Gly Gly Gly Ser Ser Tyr Val
 5 130 135 140
 ctg act cag cca ccc tcg gtg tca ggg tct cct gga cag tcg atc acc 481
 10 Leu Thr Gln Pro Pro Ser Val Ser Gly Ser Pro Gly Gln Ser Ile Thr
 145 150 155
 atc tcc tgc act gga acc agc agt gac gtt ggt tat aac tat gtc 529
 15 Ile Ser Cys Thr Gly Thr Ser Ser Asp Val Gly Gly Tyr Asn Tyr Val
 160 165 170
 tec tgg tac caa cag cac cca ggc aaa gcc ccc aaa ctc atg att tat 577
 20 Ser Trp Tyr Gln Gln His Pro Gly Lys Ala Pro Lys Leu Met Ile Tyr
 175 180 185
 gag ggc agt aaa cgg ccc tca ggg gtt tct aat cgc ttc tct ggc tcc 625
 Glu Gly Ser Lys Arg Pro Ser Gly Val Ser Asn Arg Phe Ser Gly Ser
 25 190 195 200 205
 aag tct ggc aac acg gcc tcc ctg acc atc tct ggg ctc cag gct gag 673
 30 Lys Ser Gly Asn Thr Ala Ser Leu Thr Ile Ser Gly Leu Gln Ala Glu
 35 210 215 220
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 40 Asp Glu Ala Asp Tyr Tyr Cys Ser Ser Tyr Thr Thr Arg Ser Thr Arg
 225 230 235
 gtg ttc ggc gga ggg acc aag ctg acc gtc cta gac tac aag gat gac 769
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 50 gac gat aag tgataagcgg ccgc 792
 Asp Asp Lys
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 55

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40 g 61
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50 <223> sc12E10, Single chain Fv
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<400> 113

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 1 5 10
 10 ccc aga tgg gtc ctg tcc cag gtg cag cag tcg ggc cca gga 97
 Pro Arg Trp Val Leu Ser Gln Val Gln Leu Gln Gln Ser Gly Pro Gly
 15 20 25
 15 ctg gtg aag cct tcg gag acc ctg tcc ctc acc tgc act gtc tct ggt 145
 Leu Val Lys Pro Ser Glu Thr Leu Ser Leu Thr Cys Thr Val Ser Gly
 20 30 35 40 45
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 25 50 55 60
 aag gga ctg gag tgg att ggg tat atc tat tac agt ggg agc acc aac 241
 30 Lys Gly Leu Glu Trp Ile Gly Tyr Ile Tyr Tyr Ser Gly Ser Thr Asn
 65 70 75
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 35 Tyr Asn Pro Ser Leu Lys Ser Arg Val Thr Ile Ser Val Asp Thr Ser
 80 85 90
 40 aag agc cag ttc tcc ctg aag ctg agc tct gtg acc gcc gca gac acg 337
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 95 100 105
 45 gcc gtg tat tac tgt gcg aga ggg cgg tac ttc gat gtc tgg ggc cgt 385
 Ala Val Tyr Tyr Cys Ala Arg Gly Arg Tyr Phe Asp Val Trp Gly Arg
 50 110 115 120 125
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 55 130 135 140

5 ggt tcg ggt ggt ggc gga tcg tcc tat gtg ctg act cag cca ccc tcg 481
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 255 260 265
 50 ccgc 822

55 **Claims**

1. A modified antibody comprising two or more H chain V regions and two or more L chain V regions of antibody and showing TPO agonist action by crosslinking TPO receptor.

2. The modified antibody of claim 1, wherein the H chain V region and the L chain V region are connected through a linker.
- 5 3. The modified antibody of claim 2 or 3, wherein the linker is a peptide linker comprising at least one amino acid.
4. The modified antibody of any one of claims 1 to 3, wherein the modified monoclonal antibody is a multimer of single chain Fv comprising an H chain V region and an L chain V region.
- 10 5. The modified antibody of claim 4, wherein the modified antibody is composed of tetramer, trimer or dimer of single chain Fv.
6. The modified antibody of claim 5, wherein the modified antibody is composed of dimer of single chain Fv.
- 15 7. The modified antibody of any one of claims 4 to 6, wherein the H chain V region and the L chain V region existing in the same chain are not associated to form an antigen-binding site.
8. The modified antibody of any one of claims 1 to 3, wherein the modified antibody is a single chain polypeptide comprising two or more H chain V regions and two or more L chain V regions.
- 20 9. The modified antibody of claim 8, wherein the modified antibody is a single chain polypeptide comprising two H chain V regions and two L chain V regions.
10. The modified antibody of any one of claims 1 to 9, wherein the modified antibody further comprises an amino acid sequence(s) for peptide purification.
- 25 11. The modified antibody of any one of claims 1 to 10, wherein the modified antibody has been purified.
12. The modified antibody of any one of claims 1 to 11, wherein H chain V region and/or L chain V region is H chain V region and/or L chain V region derived from a human antibody.
- 30 13. The modified antibody of any one of claims 1 to 11, wherein H chain V region and/or L chain V region is humanized H chain V region and/or L chain V region.
14. The modified antibody of any one of claims 1 to 13, wherein the modified antibody is mono-specific modified antibody.
- 35 15. The modified antibody of any one of claims 1 to 13, wherein the modified antibody is multi-specific modified antibody.
- 40 16. The modified antibody of claim 15, wherein the modified antibody is bi-specific modified antibody.
17. The monoclonal antibody of claim 14, wherein the L chain V region and the H chain V region are from the same monoclonal antibody.
- 45 18. The monoclonal antibody of any one of claims 1 to 17 which shows an equivalent or better agonist action (ED50) compared with the parent monoclonal antibody.
19. The monoclonal antibody of claim 18 which shows at least 2-fold agonist action (ED50) compared with the parent monoclonal antibody.
- 50 20. The monoclonal antibody of claim 19 which shows at least 10-fold agonist action (ED50) compared with the parent monoclonal antibody.
21. The monoclonal antibody of any one of claims 1 to 17 which is derived from a parent antibody having substantially no agonist action.
- 55 22. A compound comprising two or more H chain V regions and two or more L chain V regions of monoclonal antibody and showing an equivalent or better agonist action (ED50.) compared with thrombopoietin (TPO).

23. The compound of claim 22 which shows at least 2-fold agonist action (ED50) compared with TPO.
24. The compound of claim 23 which shows at least 10-fold agonist action (ED50) compared with TPO.
- 5 25. The modified monoclonal antibody or compound of any one of claims 1-24 which has ED50 of TPO agonist activity not more than 20pM.
- 10 26. The modified monoclonal antibody or compound of claim 25 which has ED50 of TPO agonist activity not more than 10pM.
- 15 27. The modified monoclonal antibody or compound of claim 26 which has ED50 of TPO agonist activity not more than 2pM.
28. The modified antibody or compound of any one of claims 1 to 27 which has intercellular adhesion action (ED50) not more than 1/10 compared with the parent antibody.
- 15 29. The modified antibody or compound of any one of claims 1 to 27 which has substantially no intercellular adhesion action.
- 20 30. A DNA which encodes the modified antibody or compound of any one of claims 1 to 29.
31. An animal cell which produces the modified antibody or compound of any one of claims 1 to 29.
- 25 32. A microorganism which produces the modified antibody or compound of any one of claims 1 to 29.
- 25 33. Use of the modified antibody or compound of any one of claims 1 to 29 as TPO agonist.
- 30 34. A method of causing an agonist action to cells by crosslinking TPO receptor using the modified antibody or compound of any one of claims 1 to 29 thereby transducing a signal into cells.
- 35 35. The method of claim 34 wherein the agonist action is proliferation, differentiation-induction or growth stimulation of megakaryocytes, platelet production or phosphorylation of TPO receptor protein.
36. A medicine comprising as active ingredient the modified antibody or compound of any one of claims 1 to 29.
- 35 37. The medicine of claim 36 which is for the treatment of thrombocytopenia.
38. Use of the modified antibody or compound of any one of claims 1 to 29 as medicine.
- 40 39. A method of screening a modified antibody comprising two or more H chain V regions and two or more L chain V regions of antibody and showing an agonist action by crosslinking TPO receptor which comprises the steps
- 45 (1) to produce a modified antibody comprising two or more H chain V regions and two or more L chain V regions of antibody and binding specifically to TPO receptor,
- (2) to subject cells expressing said TPO receptor to react with the modified antibody and
- (3) to measure TPO agonist action in the cells caused by crosslinking TPO receptor.
- 50 40. A method of measuring an agonist action of a modified antibody comprising two or more H chain V regions and two or more L chain V regions of antibody and showing an agonist action by crosslinking TPO receptor which comprises the steps
- 55 (1) to produce a modified antibody comprising two or more H chain V regions and two or more L chain V regions of antibody and binding specifically to TPO receptor,
- (2) to subject cells expressing said TPO receptor to react with the modified antibody and
- (3) to measure TPO agonist action in the cells caused by crosslinking TPO receptor.

Fig. 1

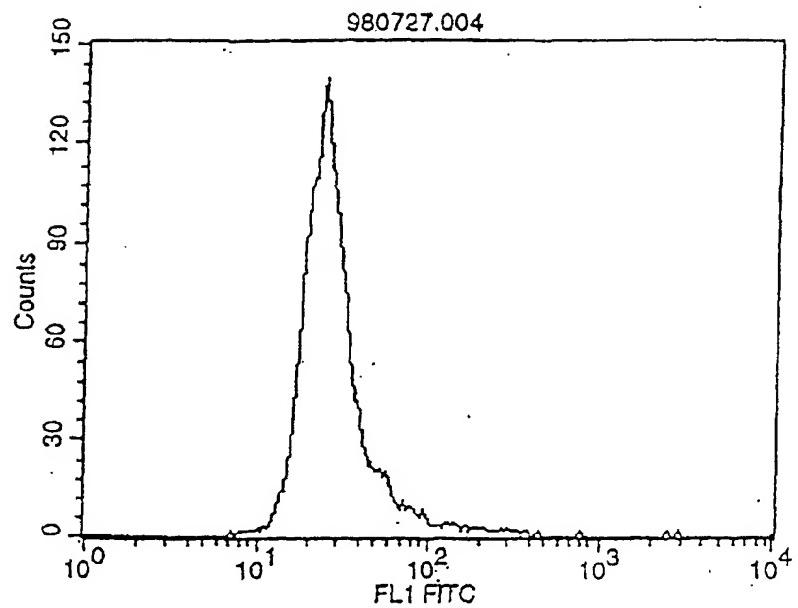


Fig. 2

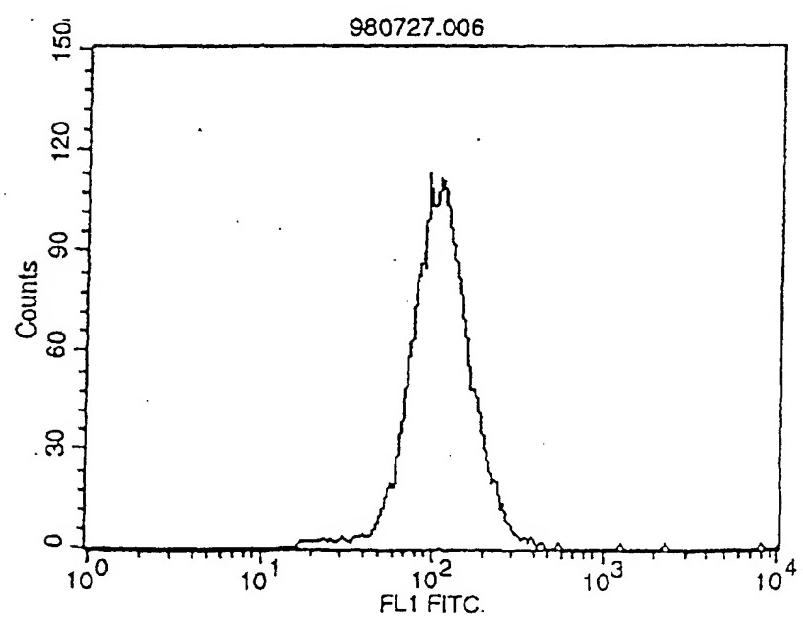


Fig. 3

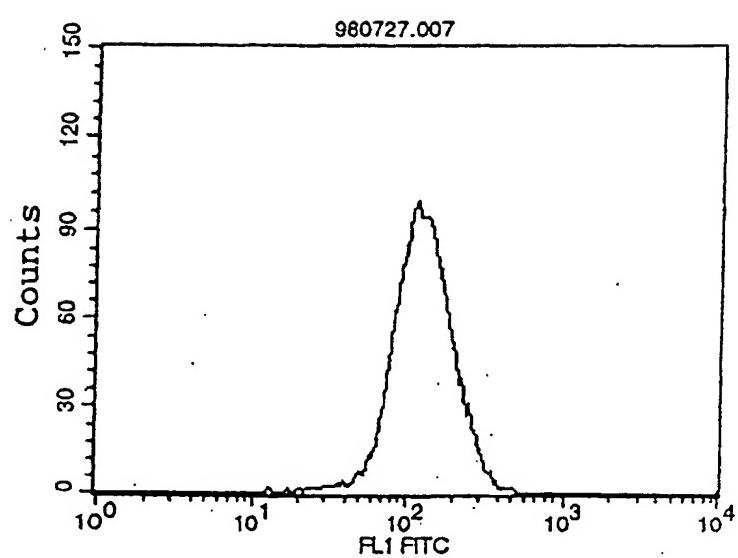


Fig. 4

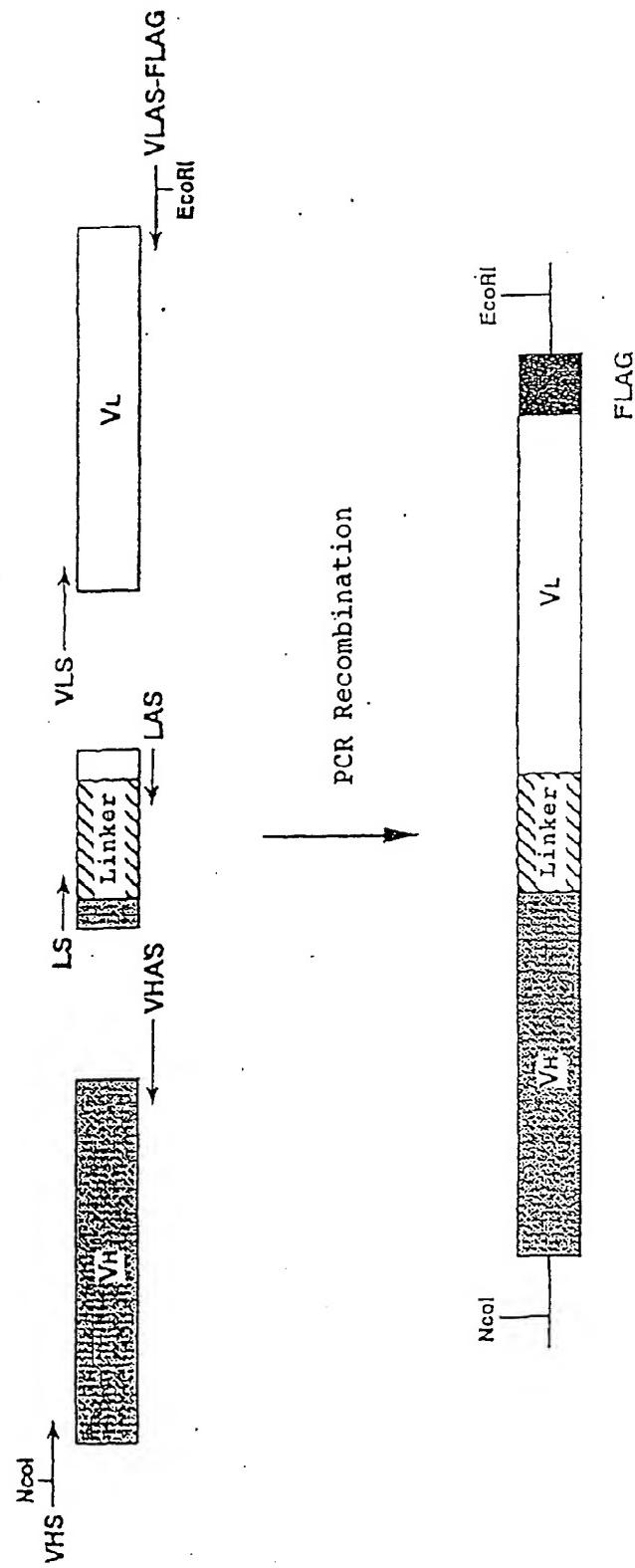


Fig. 5

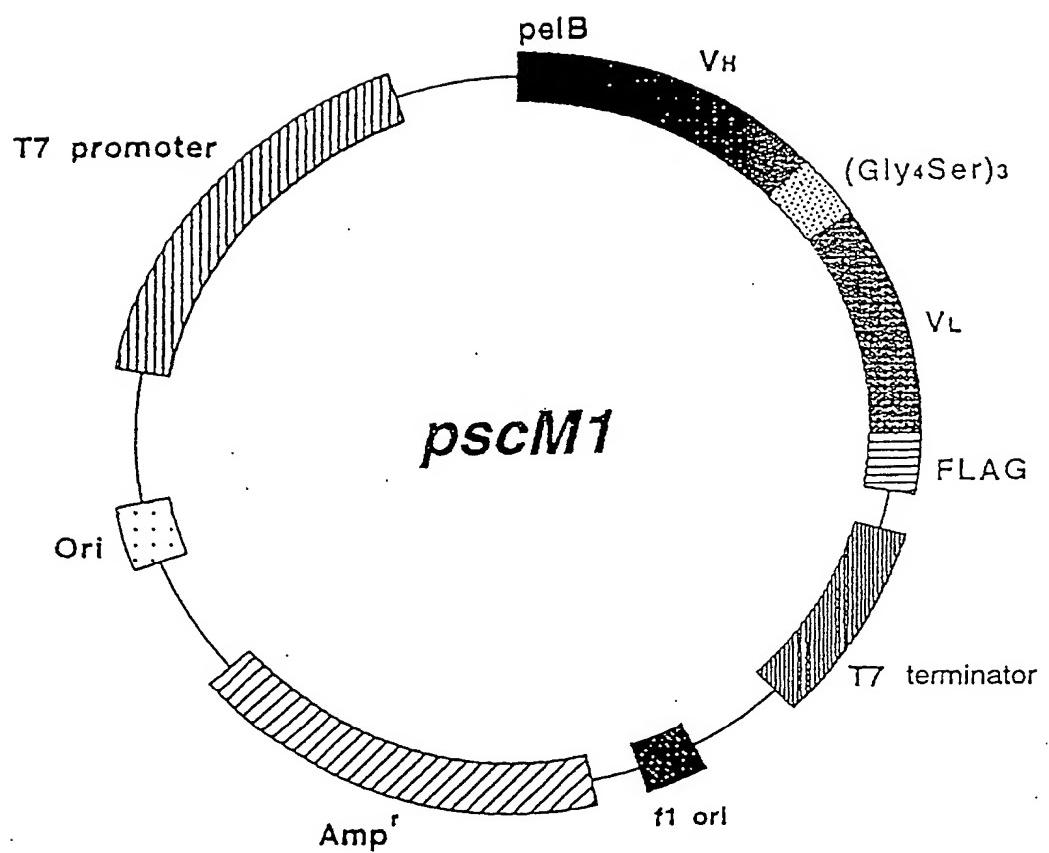


Fig. 6

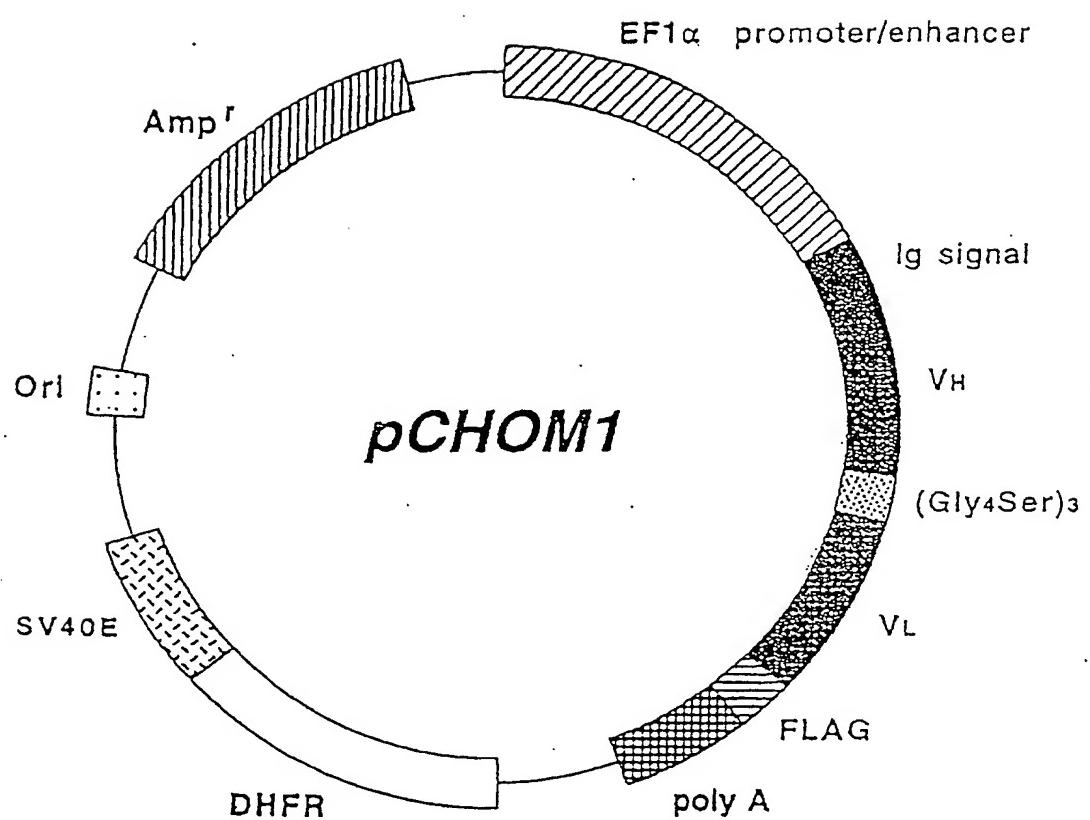


Fig. 7

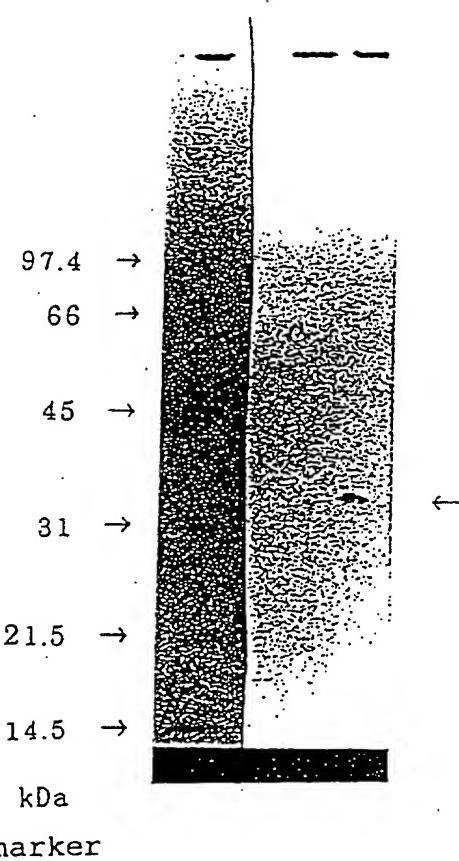


Fig. 8

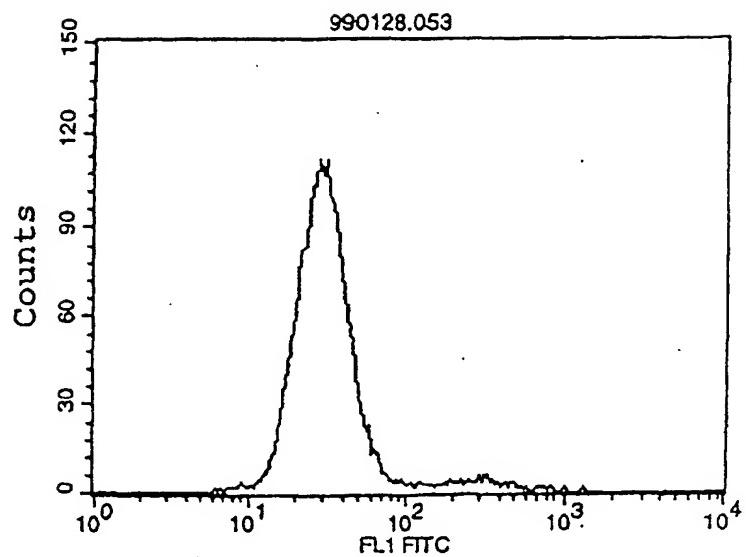


Fig. 9

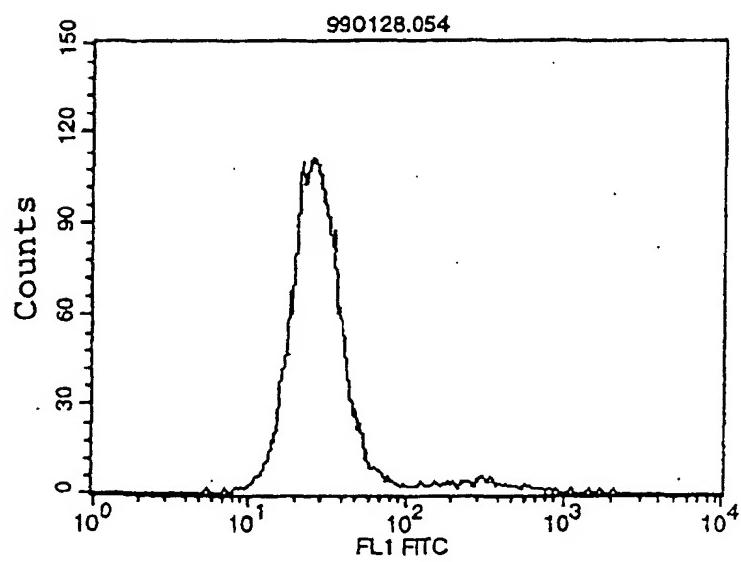


Fig. 10

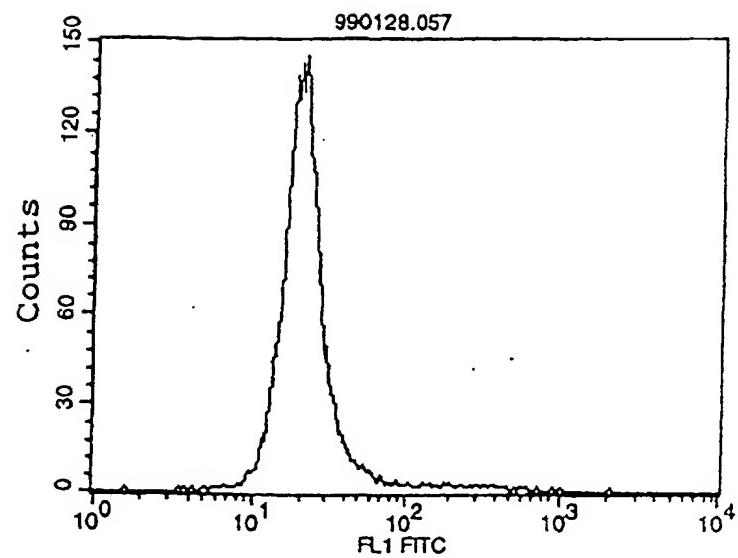


Fig. 11

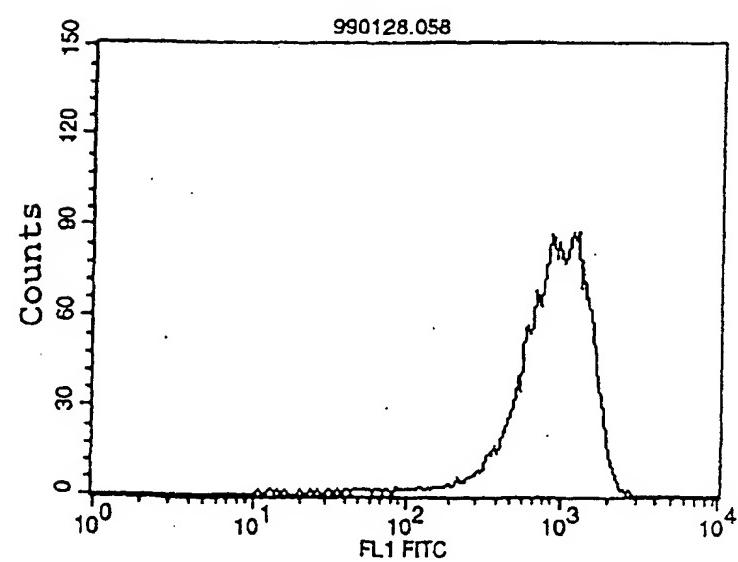


Fig. 12

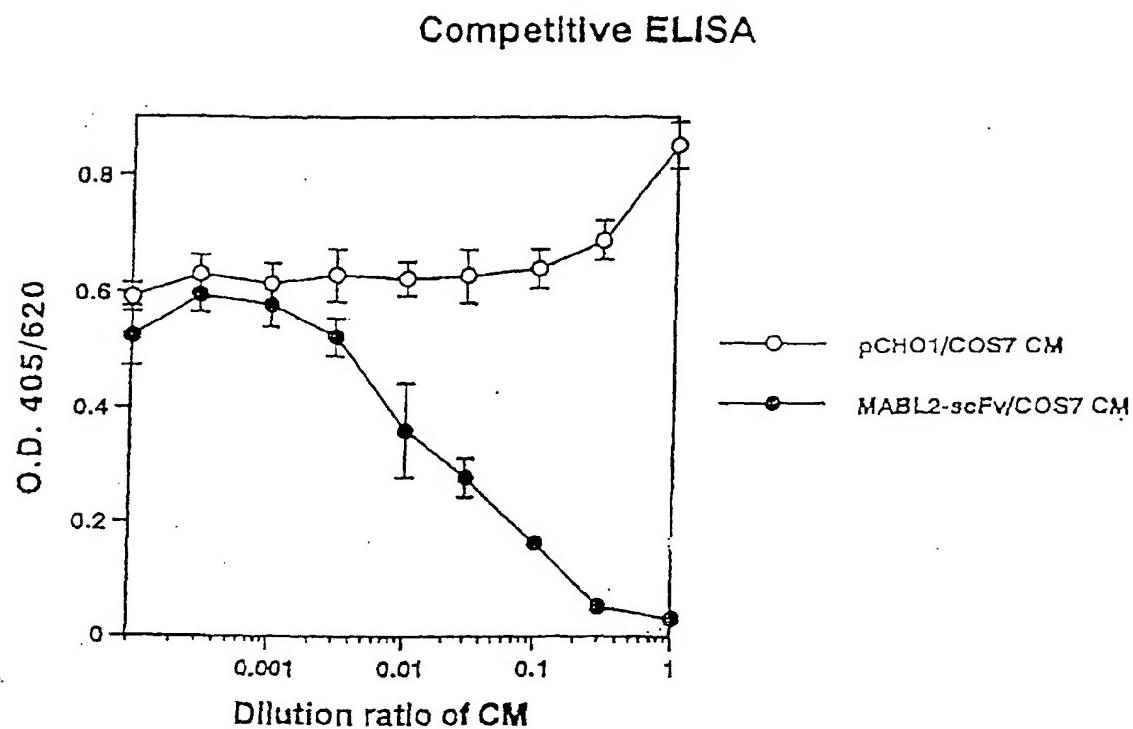


Fig. 13

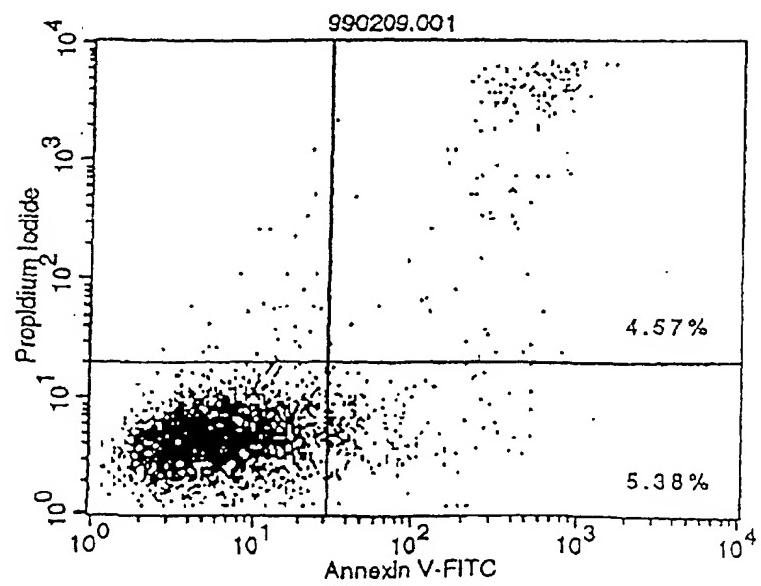


Fig. 14

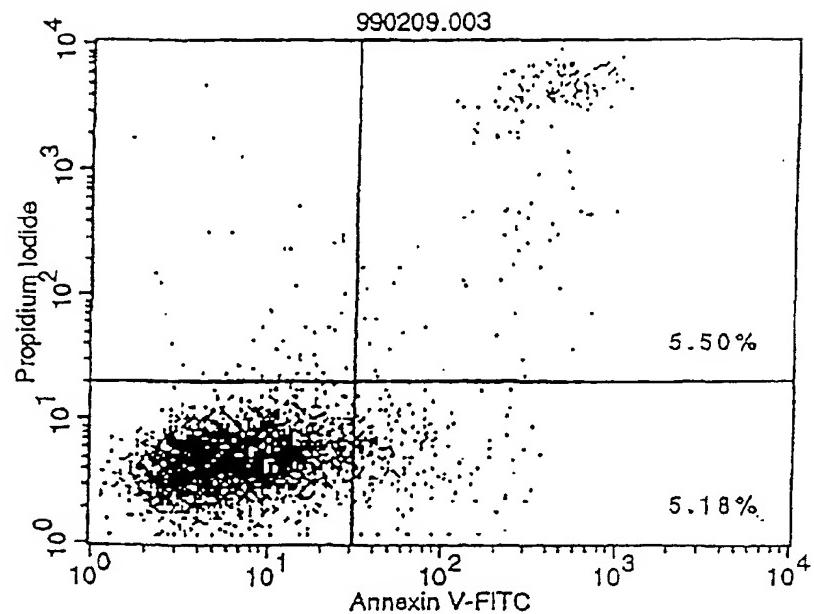


Fig. 15

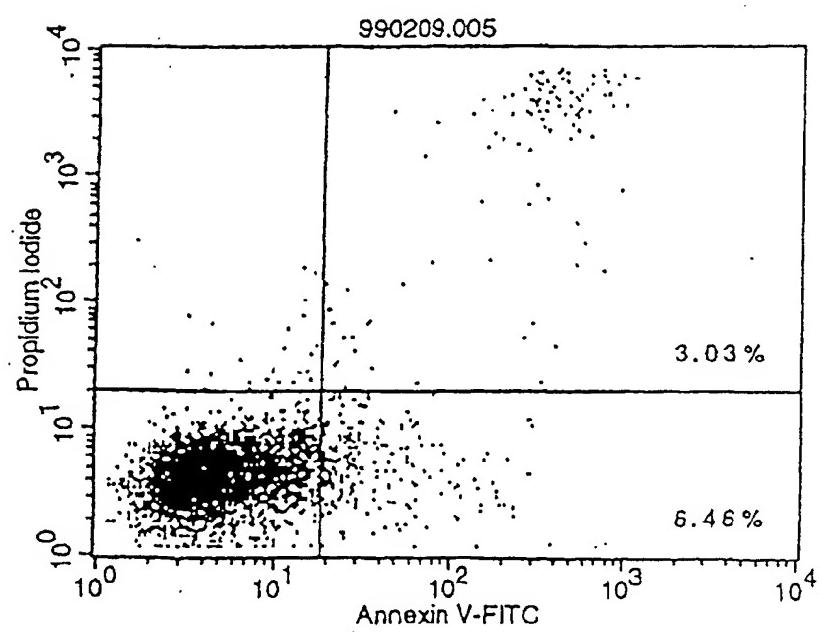


Fig. 16

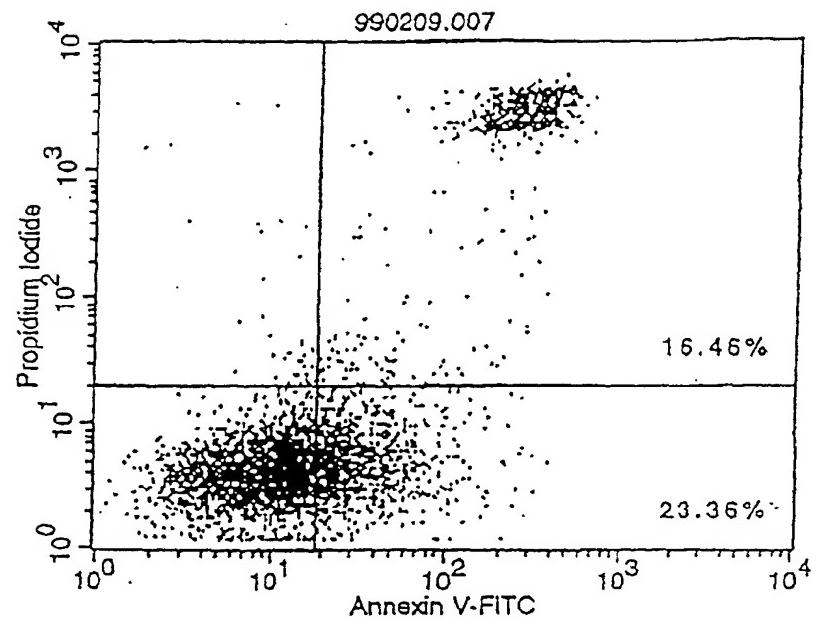


Fig. 17

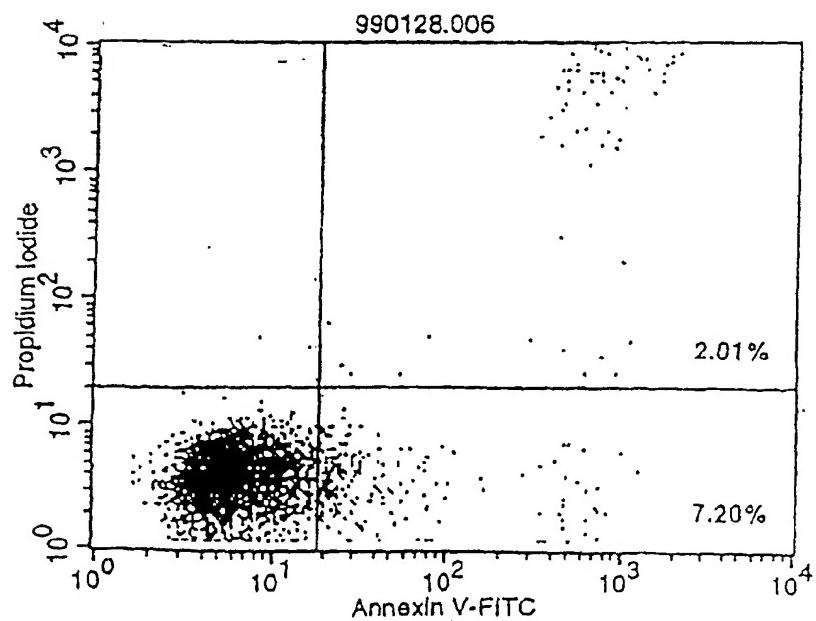


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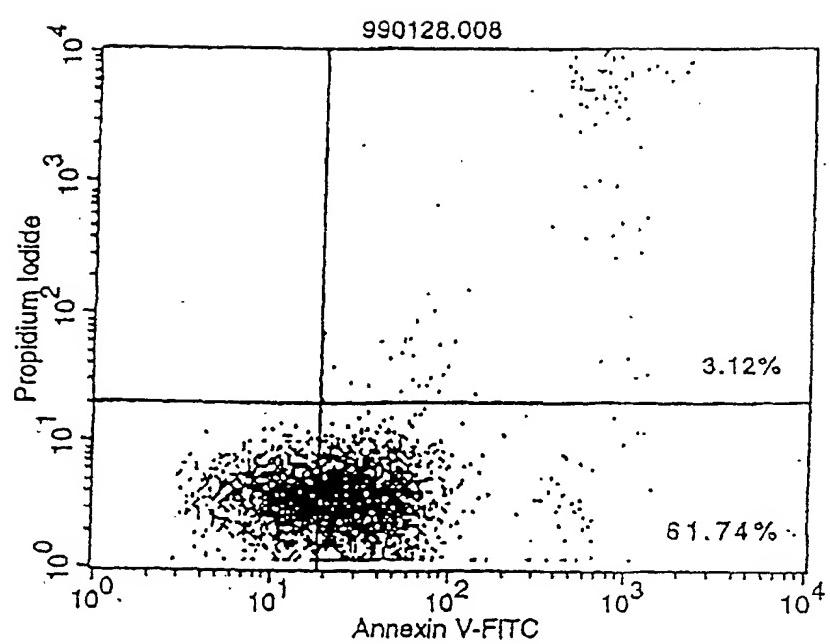


Fig. 19

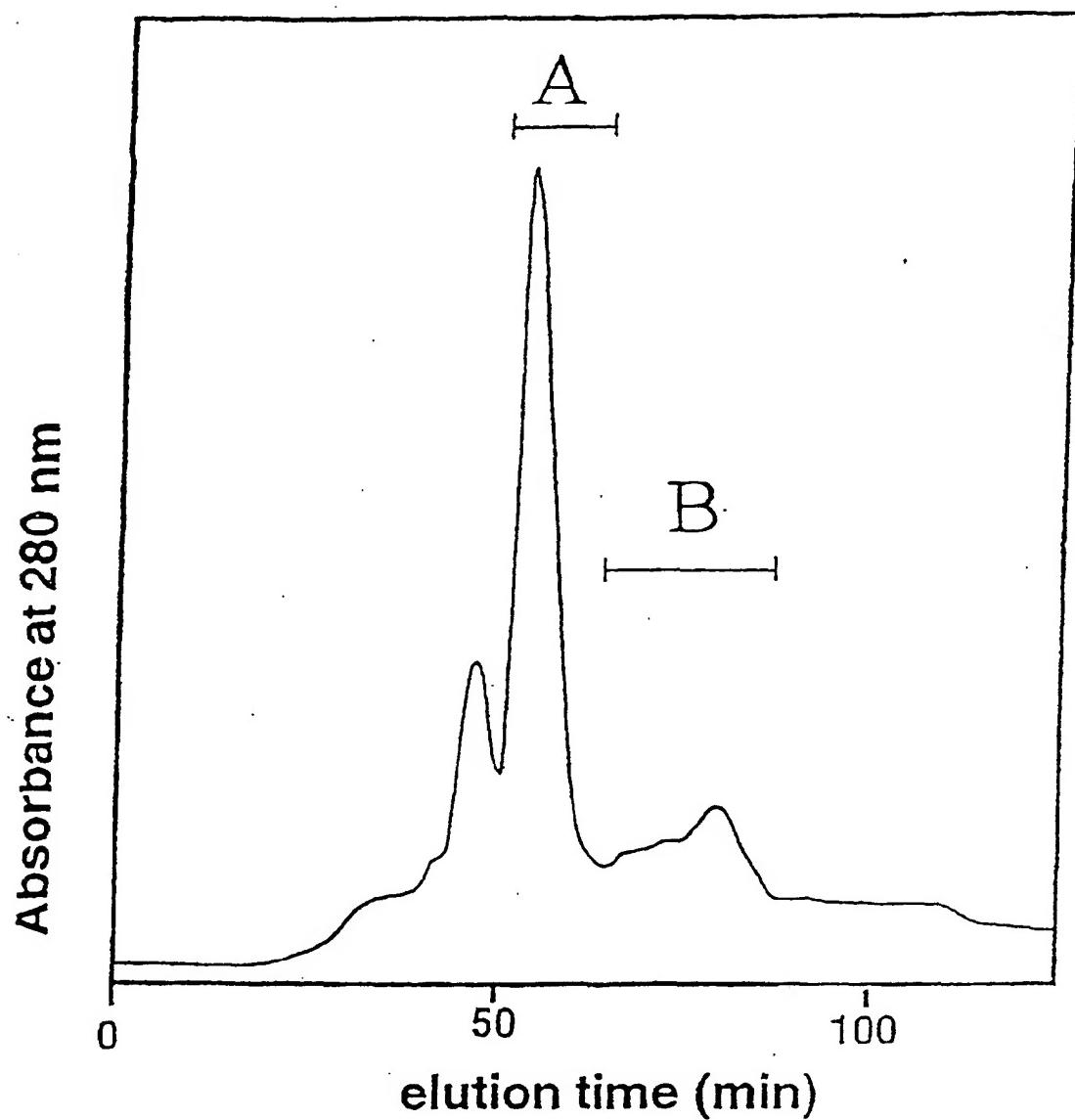


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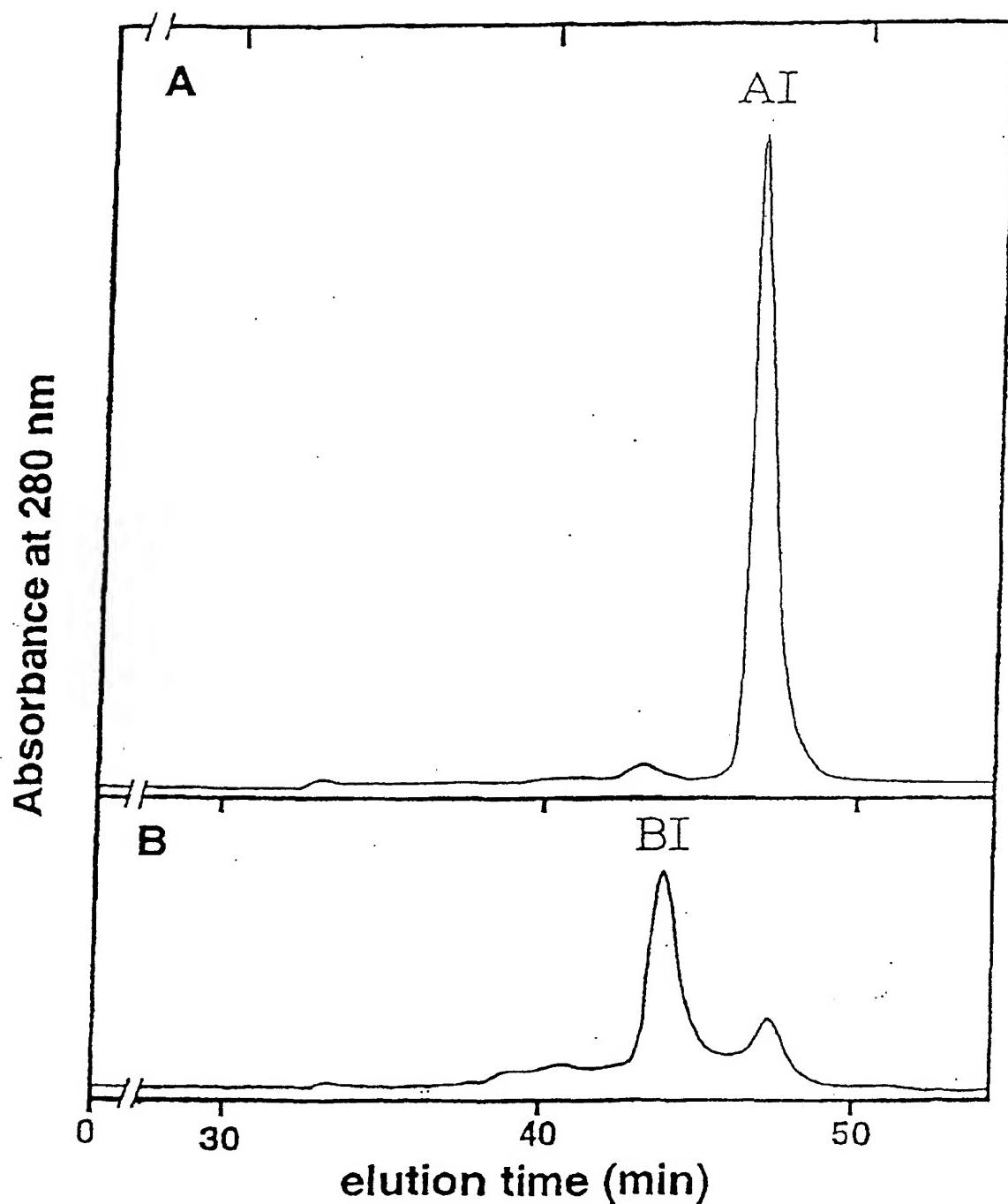
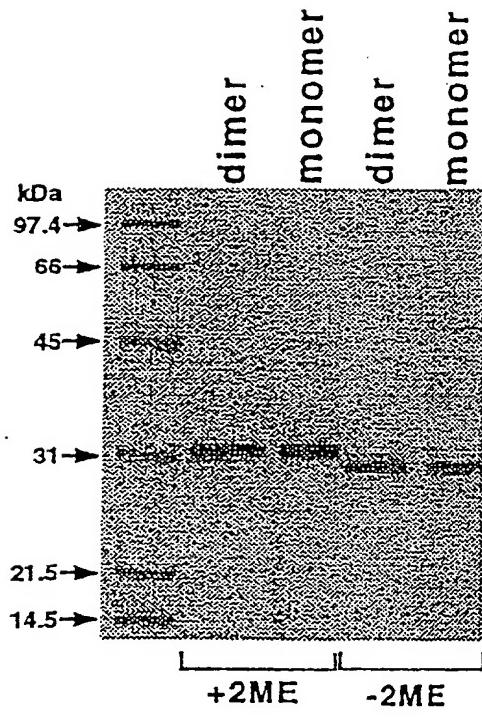


Fig. 21

SDS-PAGE analysis of MABL2-scFv

<CHO>



<E. coli>

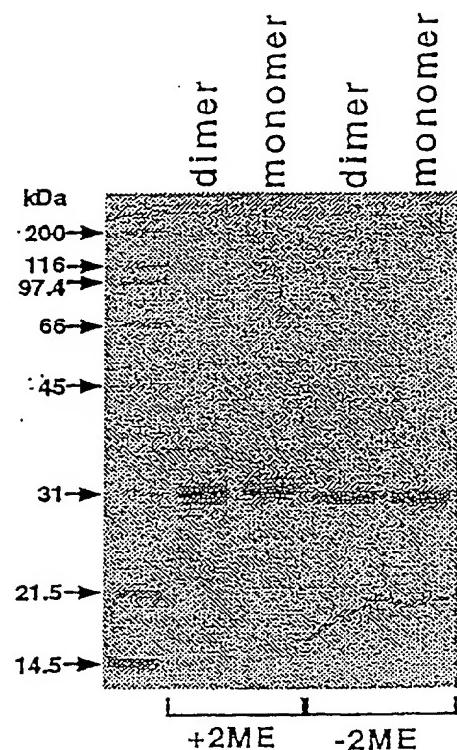


Fig. 22
TSK gel G3000SW
20 mM Acetate buffer, 0.15 M NaCl, pH 6.0

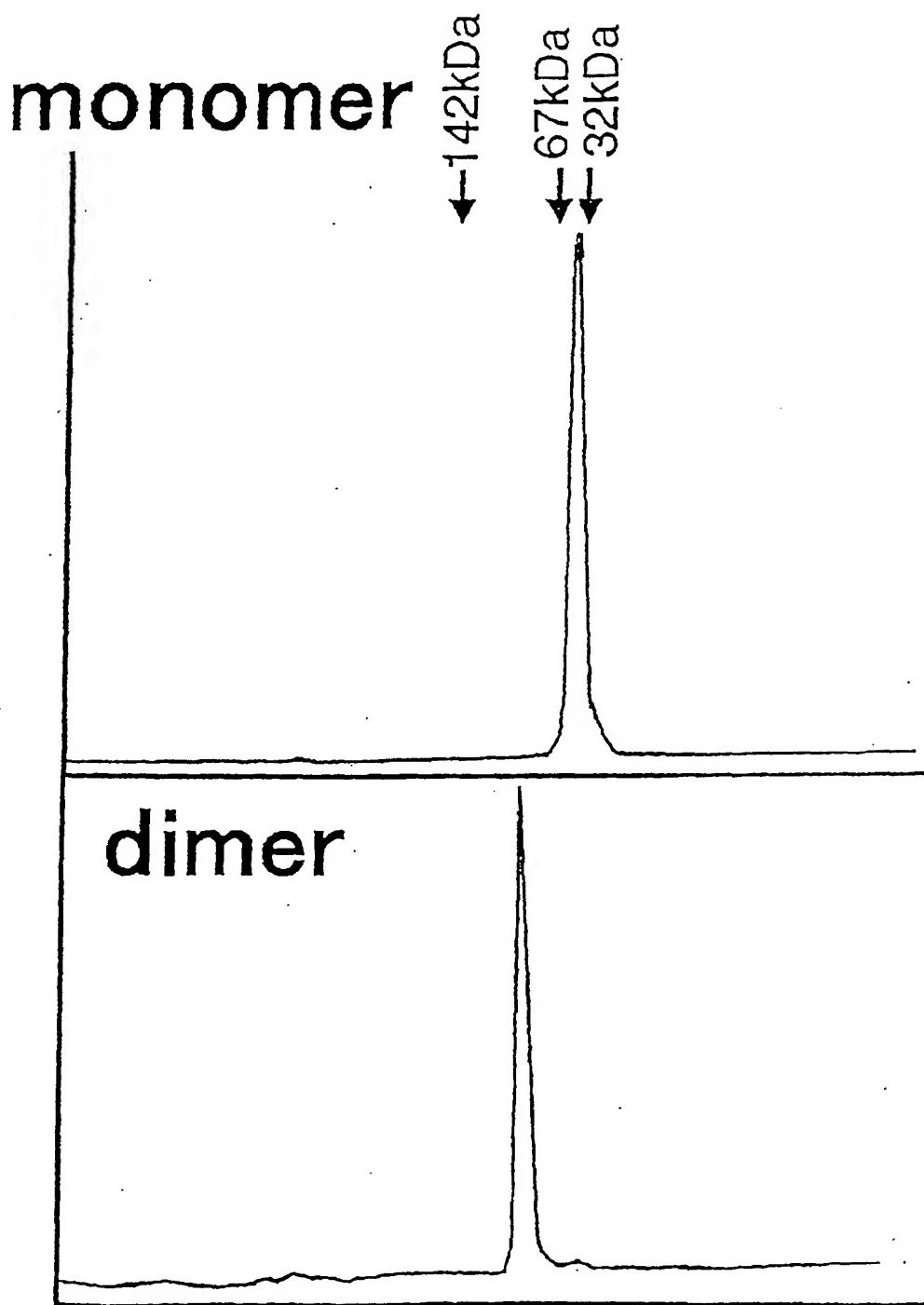


Fig. 23

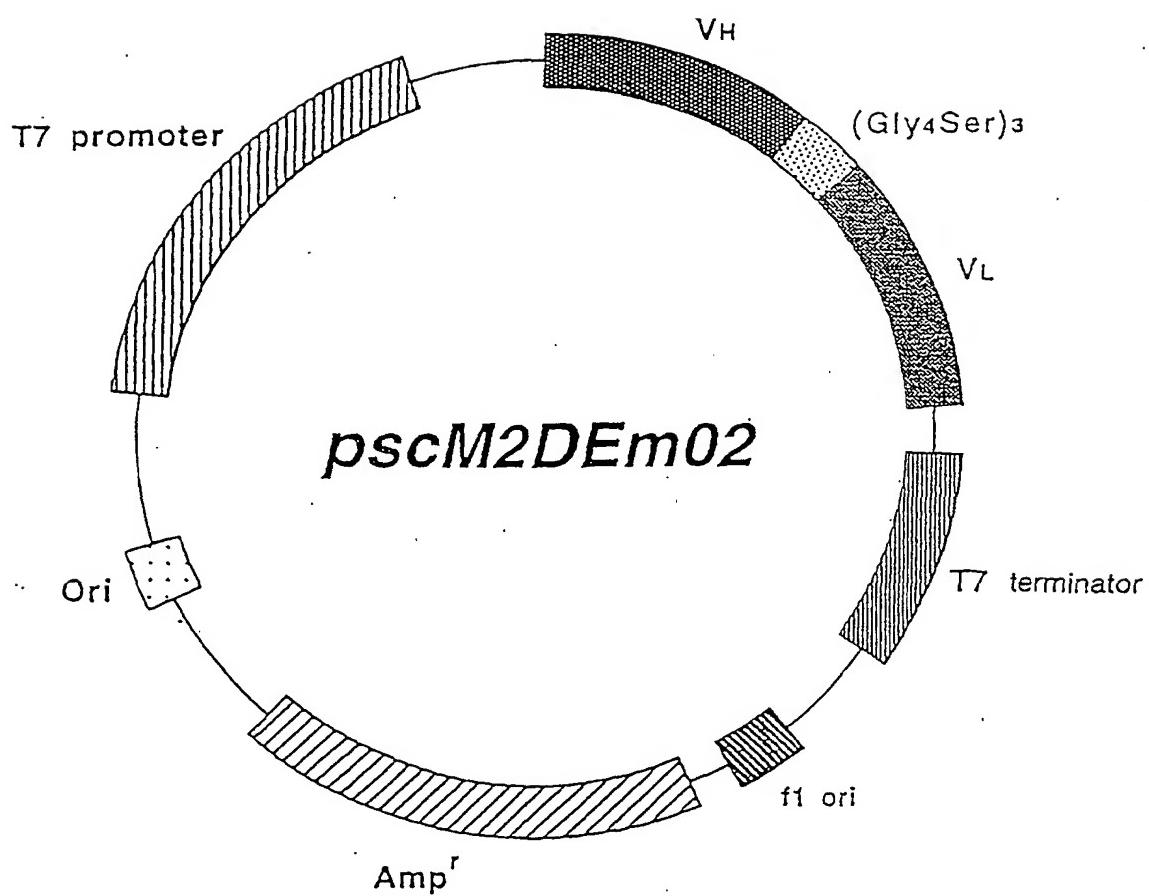


Fig. 24

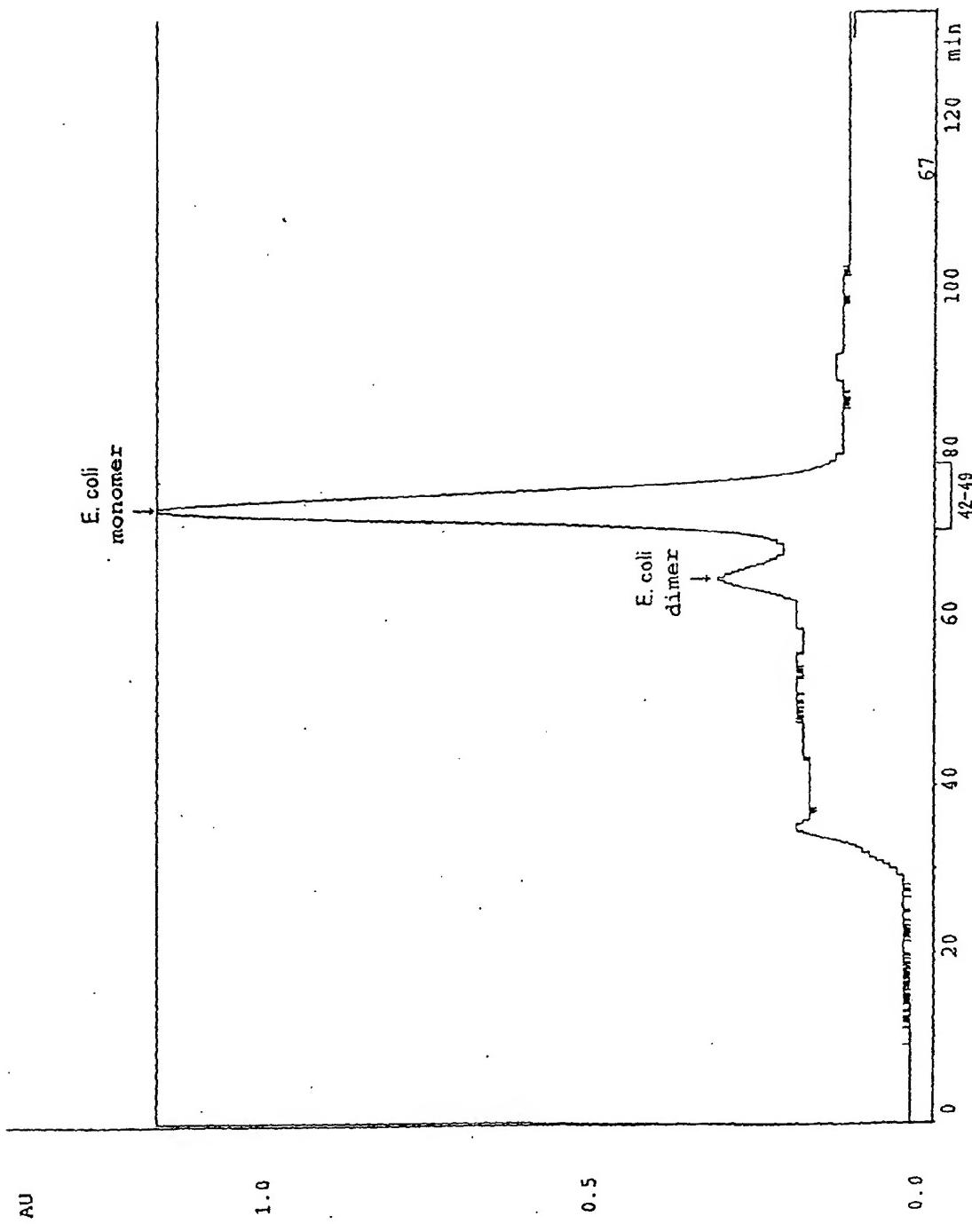


Fig. 25

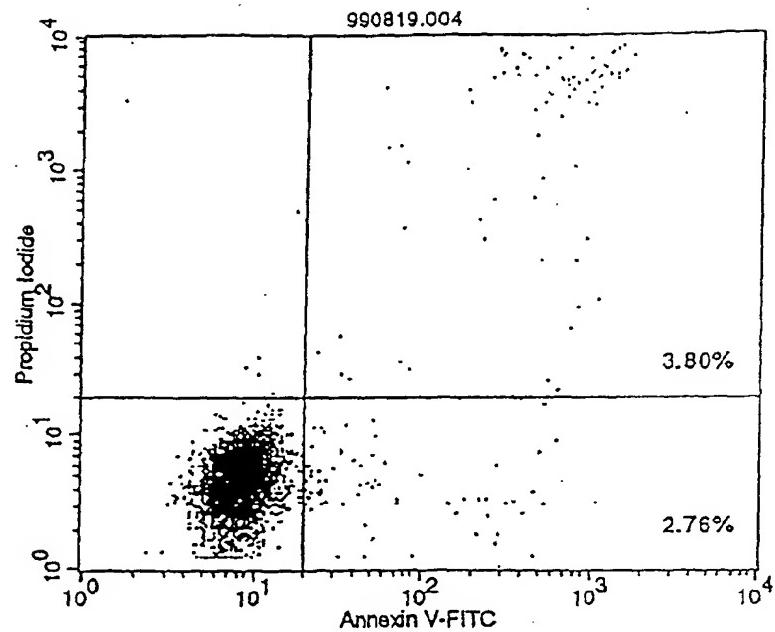


Fig. 26

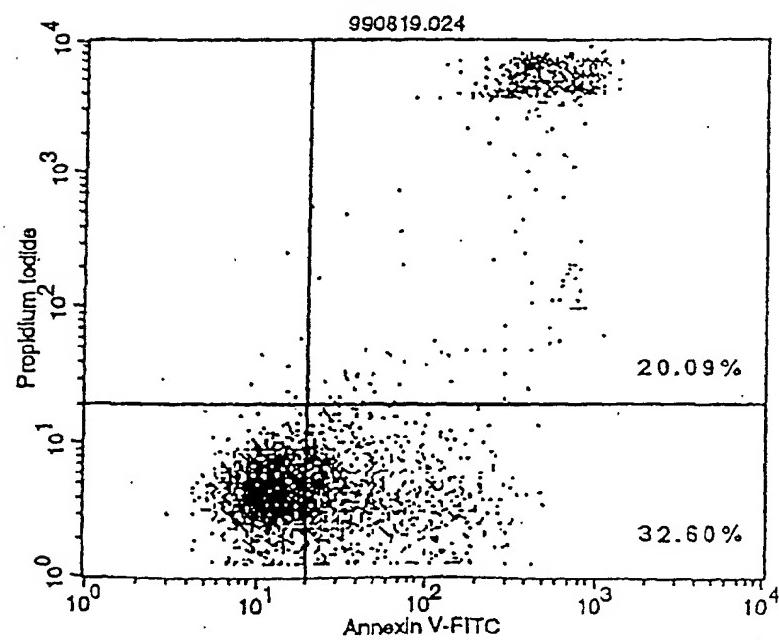


Fig. 27

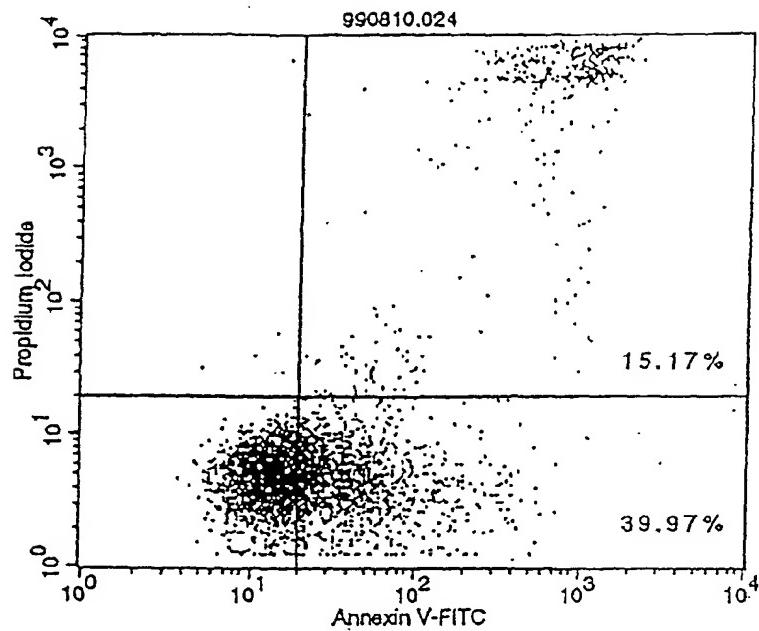


Fig. 28

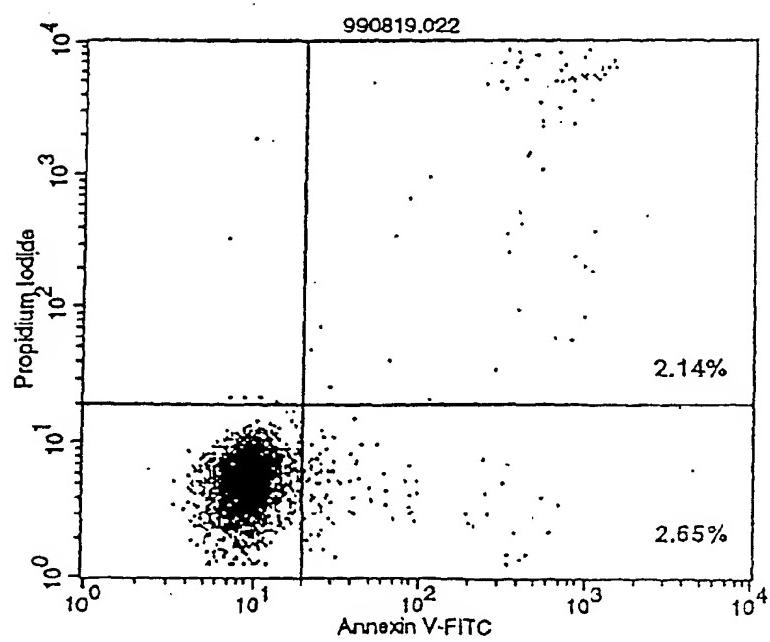


Fig. 29

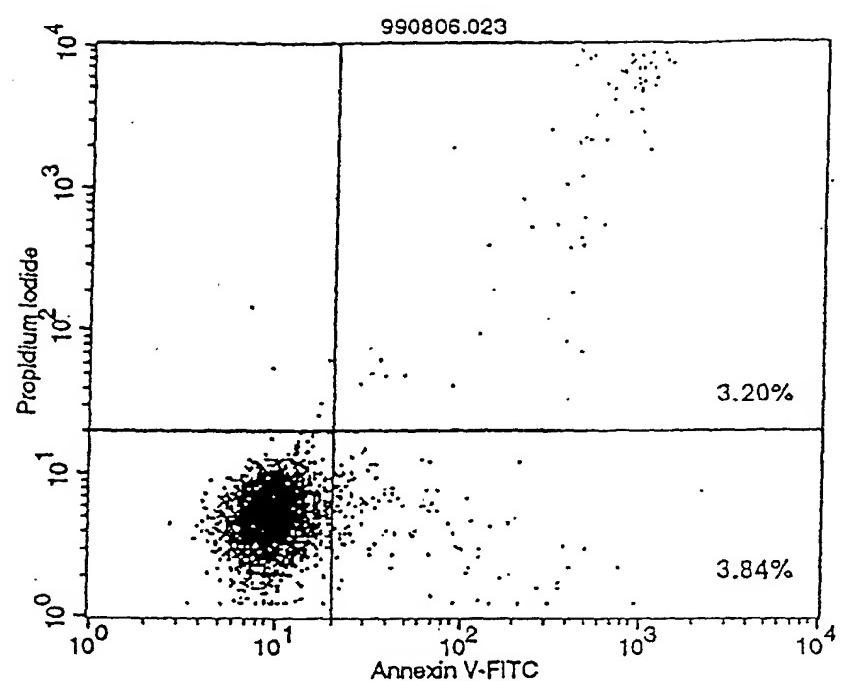


Fig. 30

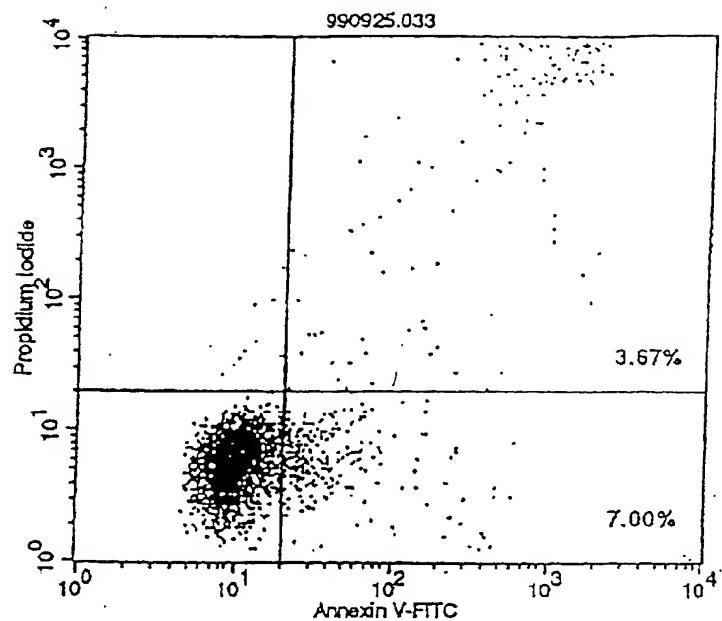


Fig. 31

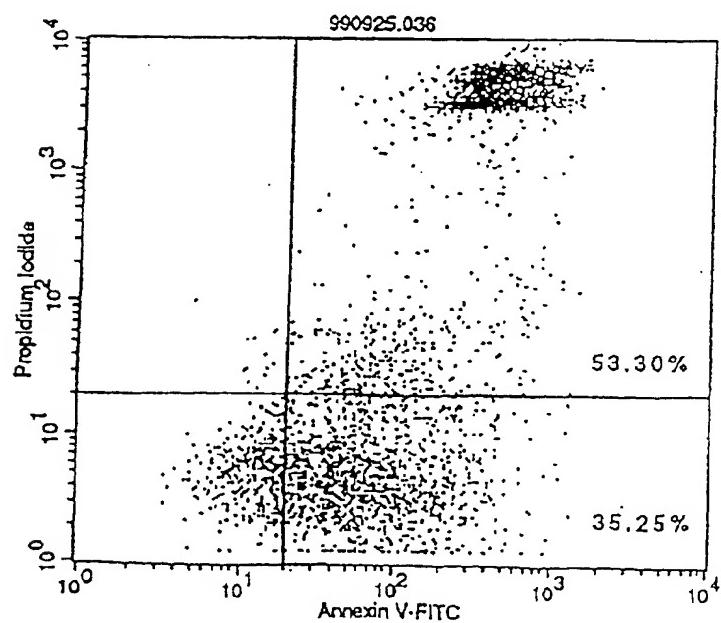


Fig. 32

*Effect of MABL-2 (scFv) on serum hIgG
in KPMM2 i.v. SCID mice*

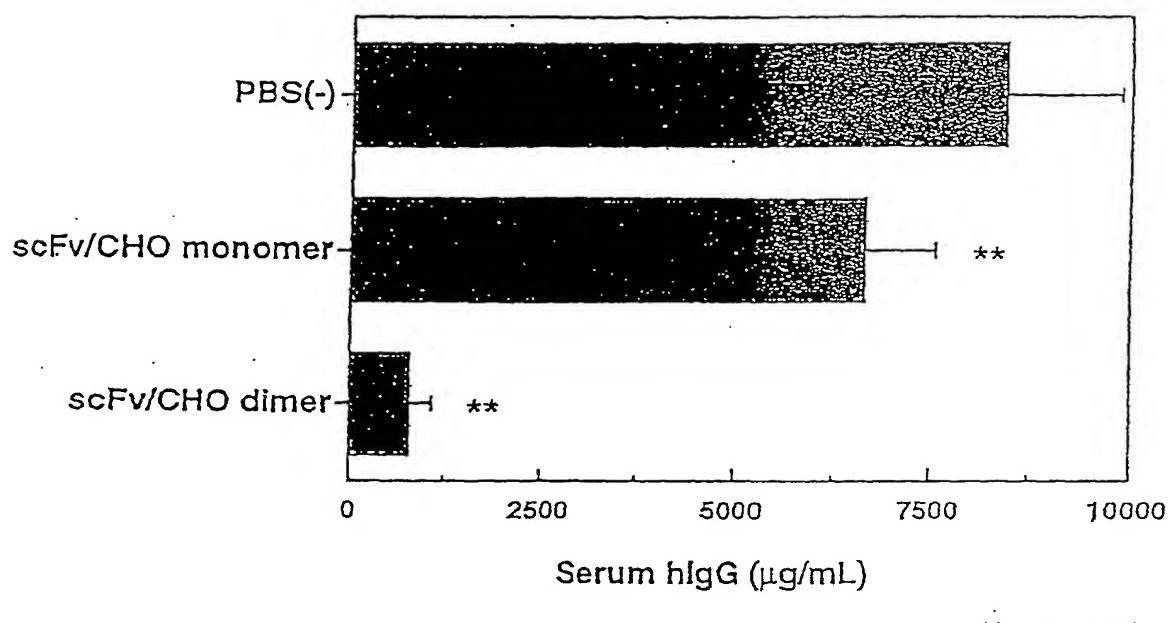
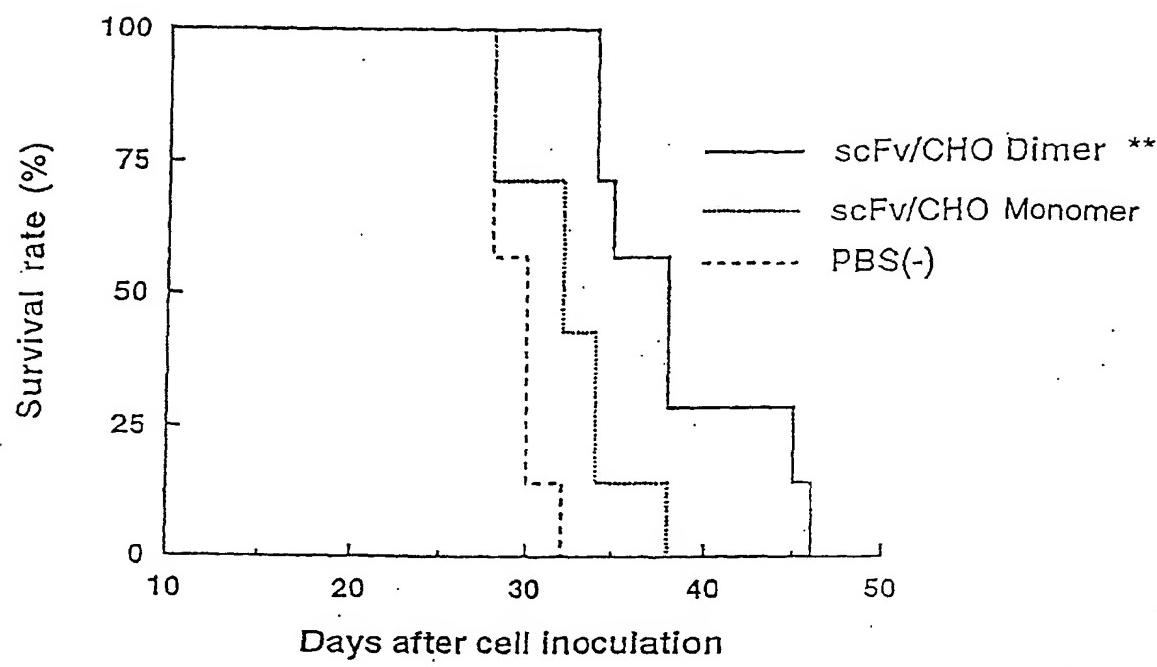


Fig. 33

*Effect of MABL-2 (scFv) on survival
of KPMM2 i.v. SCID mice*



** ; P<0.01 by t-test

Fig. 34

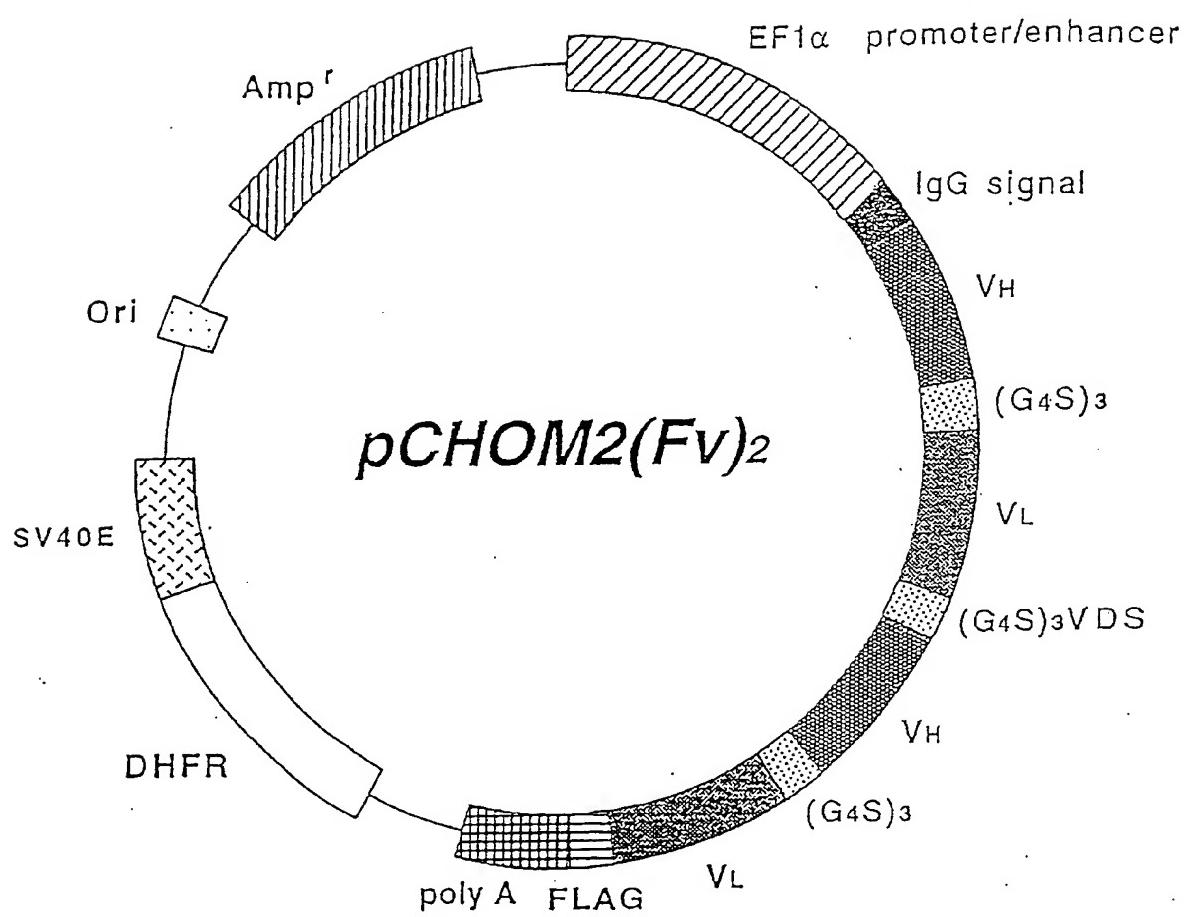


Fig. 35

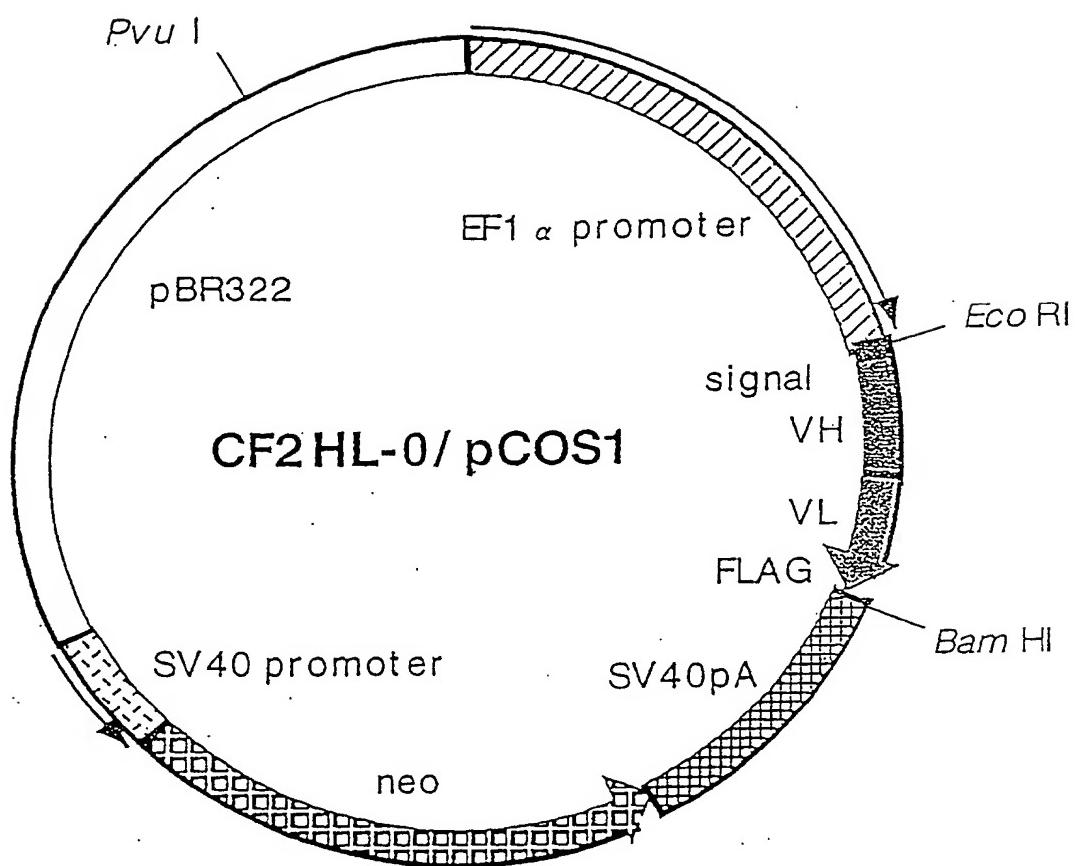
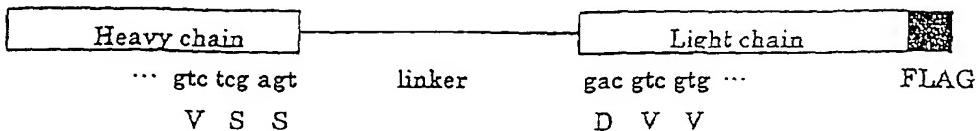


Fig. 36

Base Sequence and Amino Acid Sequence of Linker for HL Type



Plasmid	linker amino acid	Number of	
		linker	linker
CF2HL-0/pCOS1	0	gtc tcg agt V S S	gac gtc gtg D V V
CF2HL-3/pCOS1	3	gtc tcg agt ggt ggt tcc V S S G G S	gac gtc gtg D V V
CF2HL-4/pCOS1	4	gtc tcg agt ggt ggt ggt tcc V S S G G G S	gac gtc gtg D V V
CF2HL-5/pCOS1	5	gtc tcg agt ggt ggt ggt ggt tcc V S S G G G G S	gac gtc gtg D V V
CF2HL-6/pCOS1	6	gtc tcg agt gt ggt ggt ggt ggt tcc V S S G G G G G S	gac gtc gtg D V V
CF2HL-7/pCOS1	7	gtc tcg agt ggt ggt ggt ggt ggt tcc V S S G G G G G S	gac gtc gtg D V V

Fig. 37

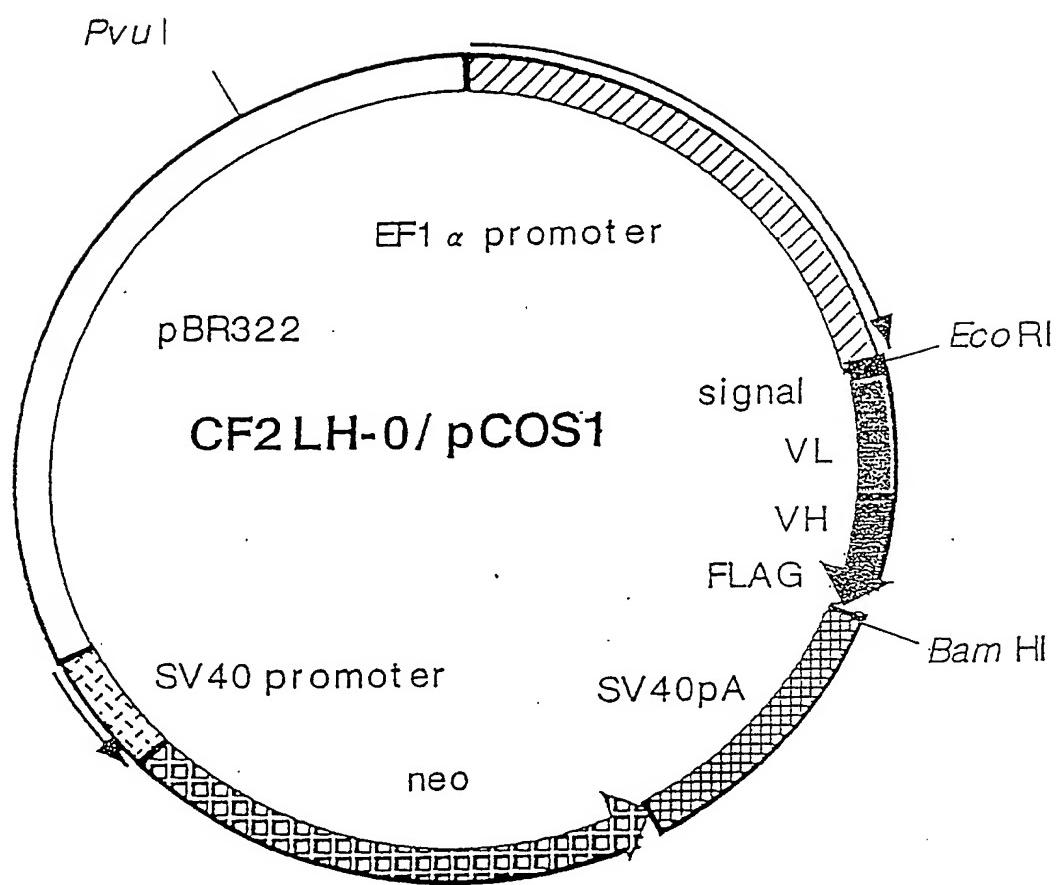
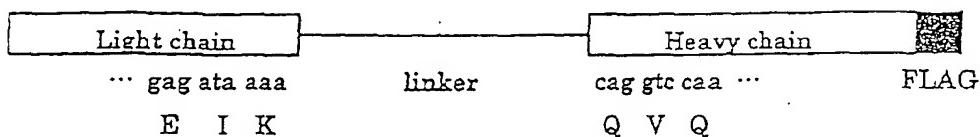


Fig. 38

Base Sequence and Amino Acid Sequence of Linker for LH Type



Plasmid	Number of		linker
	linker	amino acid	
CF2LH-0/pCOS1	0	gag ata aaa E I K	cag gtc caa Q V Q
CF2LH-3/pCOS1	3	gag ata aaa tcc gga ggc E I K S G G	cag gtc caa Q V Q
CF2LH-4/pCOS1	4	gag ata aaa tcc gga ggt ggc E I K S G G G	cag gtc caa Q V Q
CF2LH-5/pCOS1	5	gag ata aaa tcc gga ggt ggt ggc E I K S G G G G	cag gtc caa Q V Q
CF2LH-6/pCOS1	6	gag ata aaa tcc gga ggt ggt ggt ggc E I K S G G G G G	cag gtc caa Q V Q
CF2LH-7/pCOS1	7	gag ata aaa tcc gga ggt ggt ggt ggt ggc E I K S G G G G G Q V Q	cag gtc caa

Fig. 39

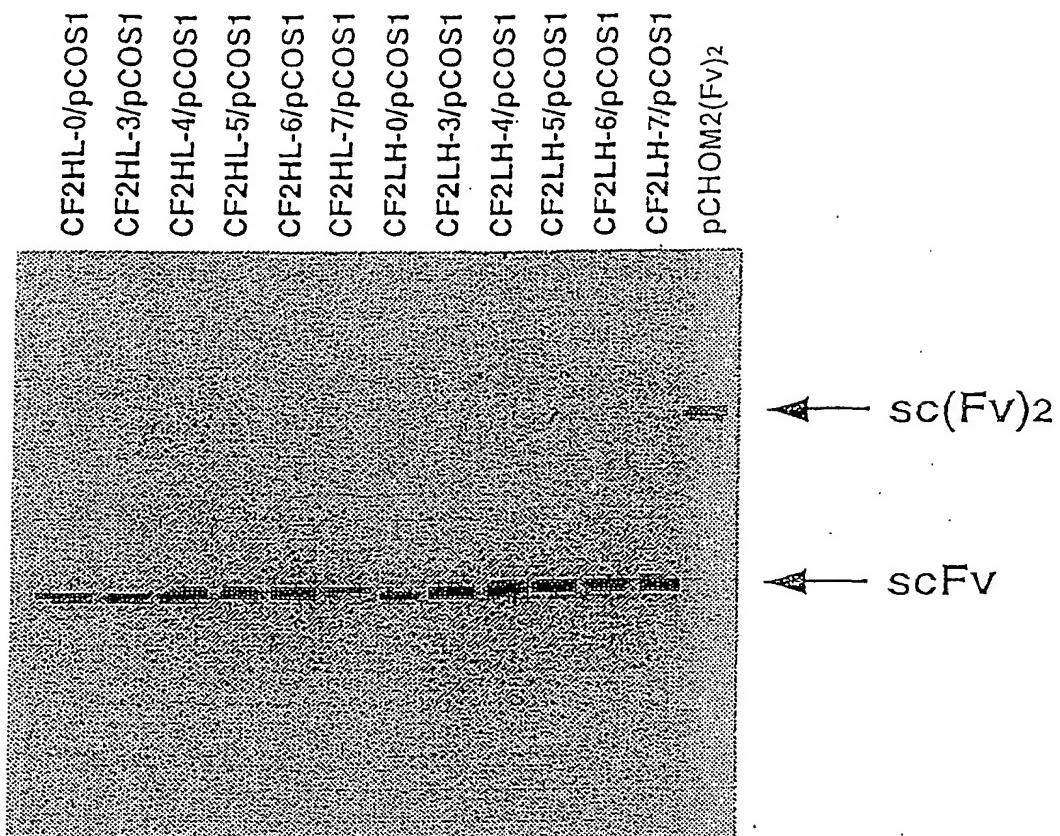


Fig. 40a

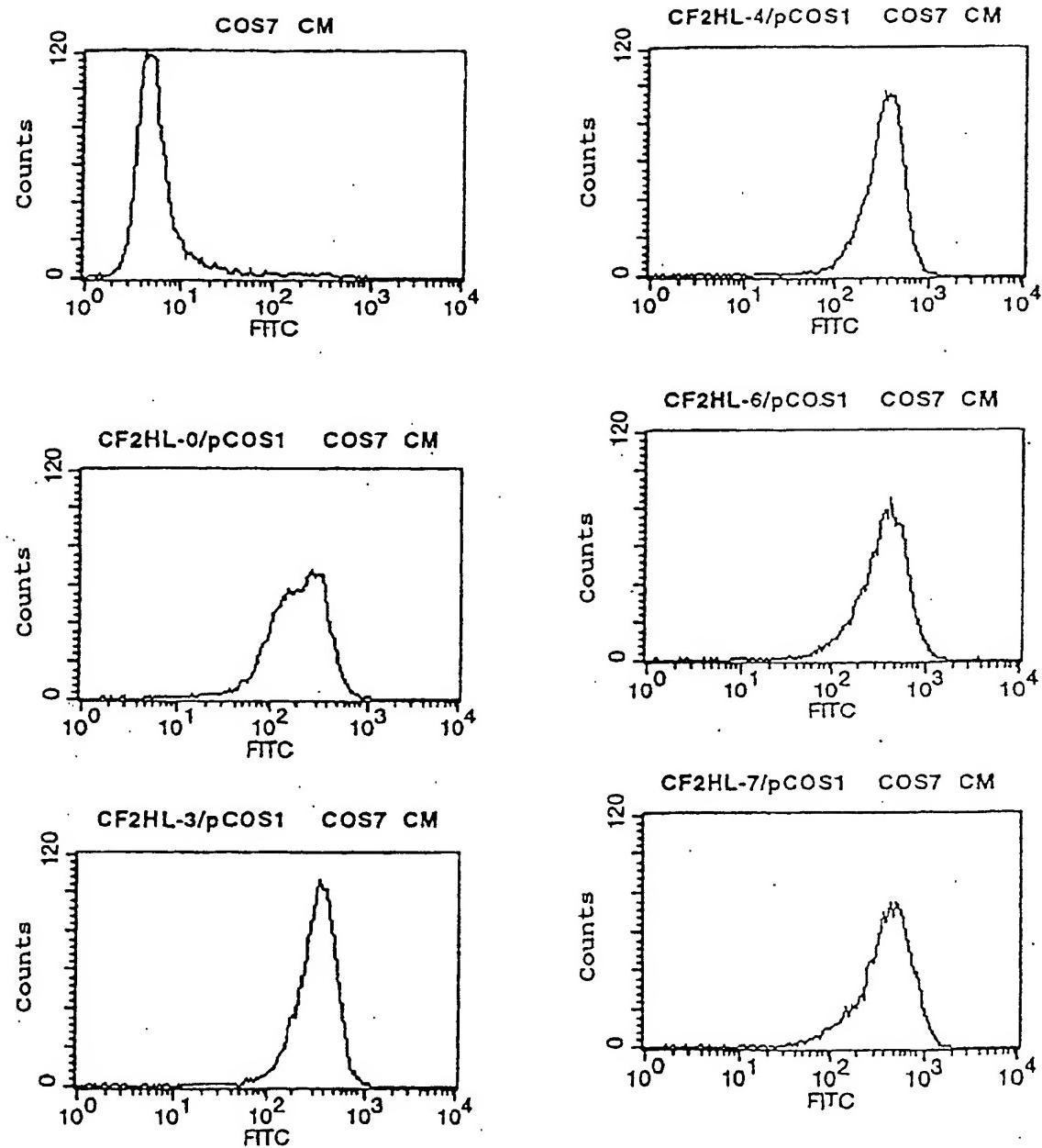


Fig. 40b

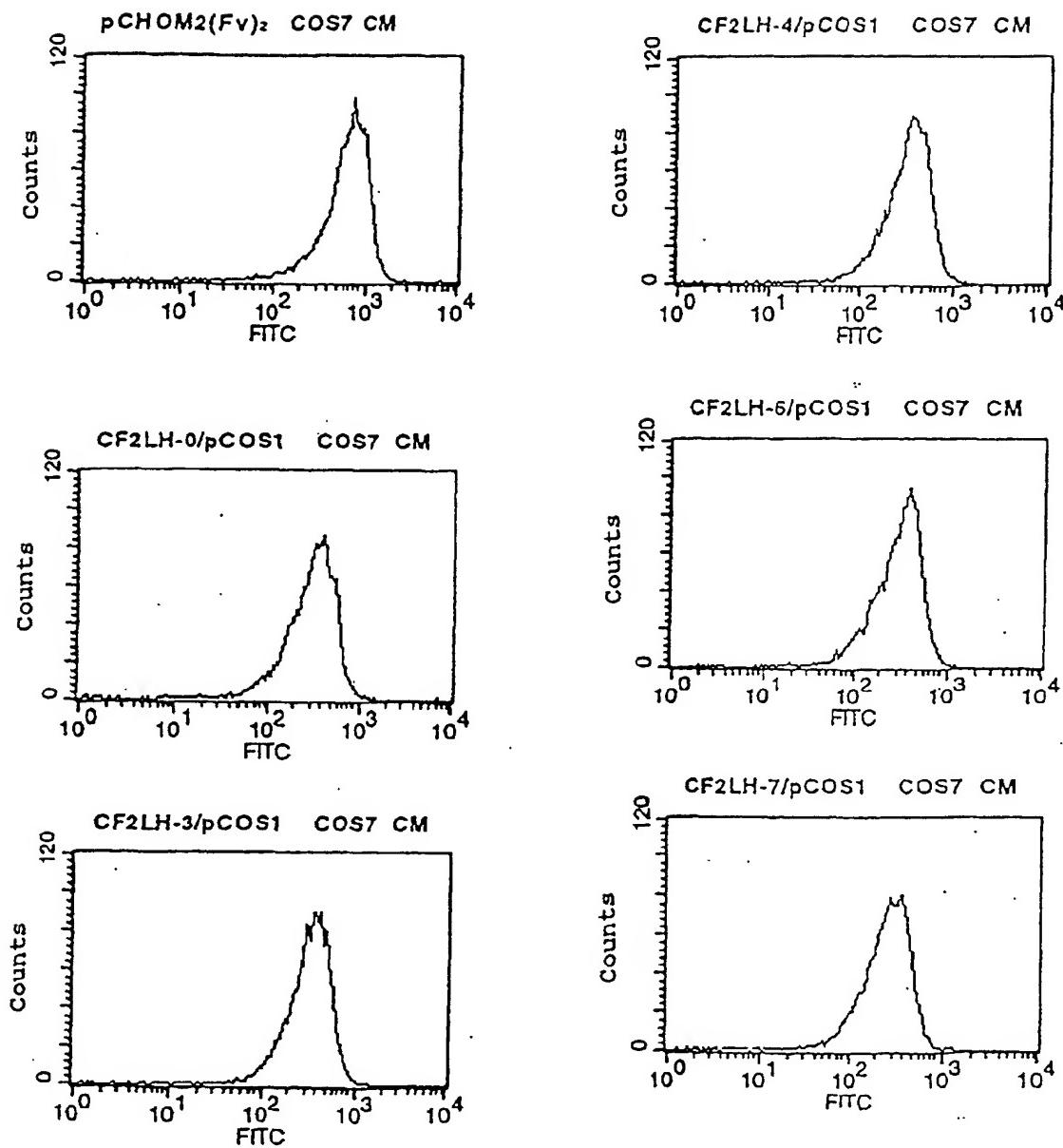


Fig. 41a

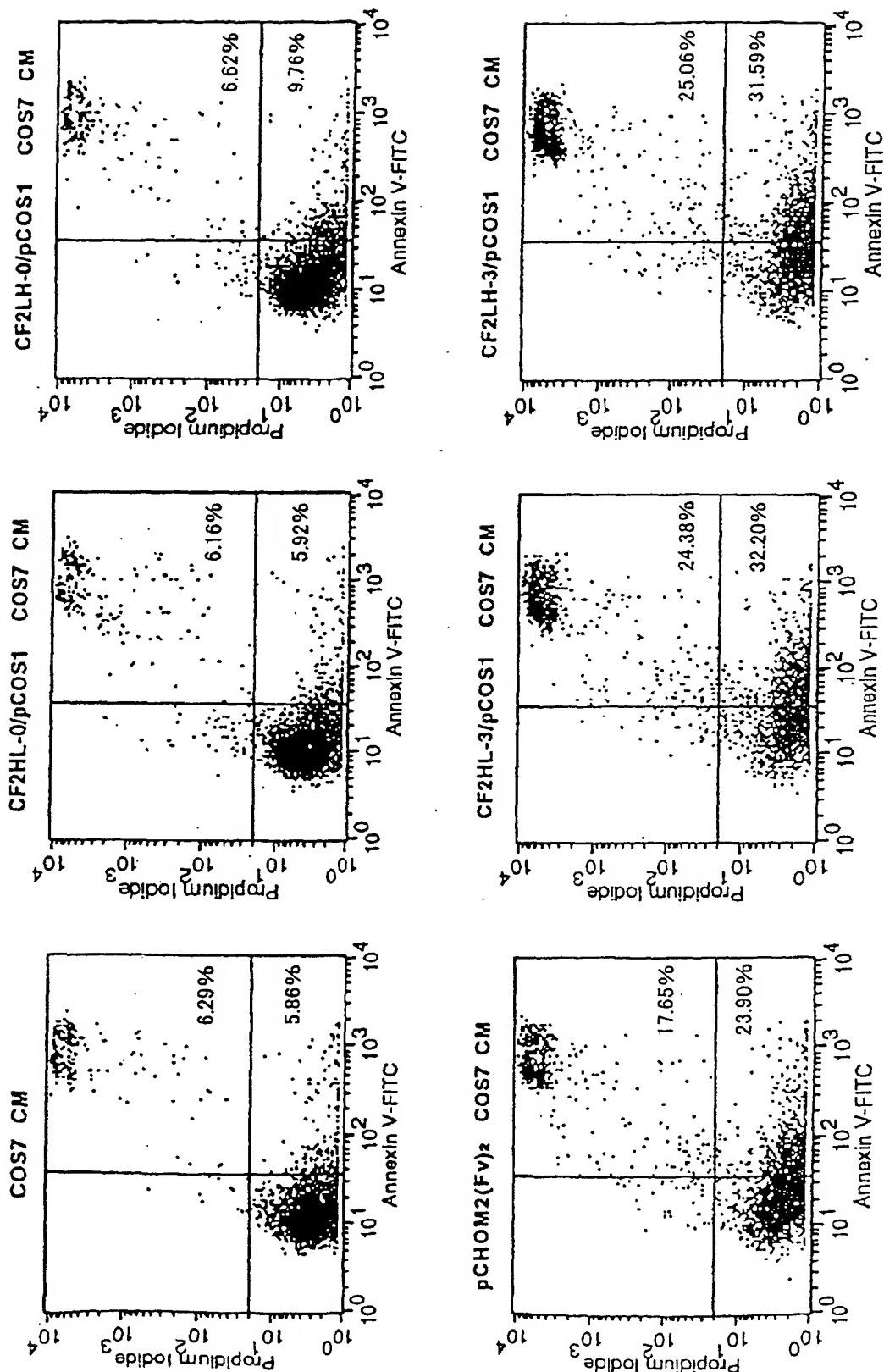


Fig. 41b

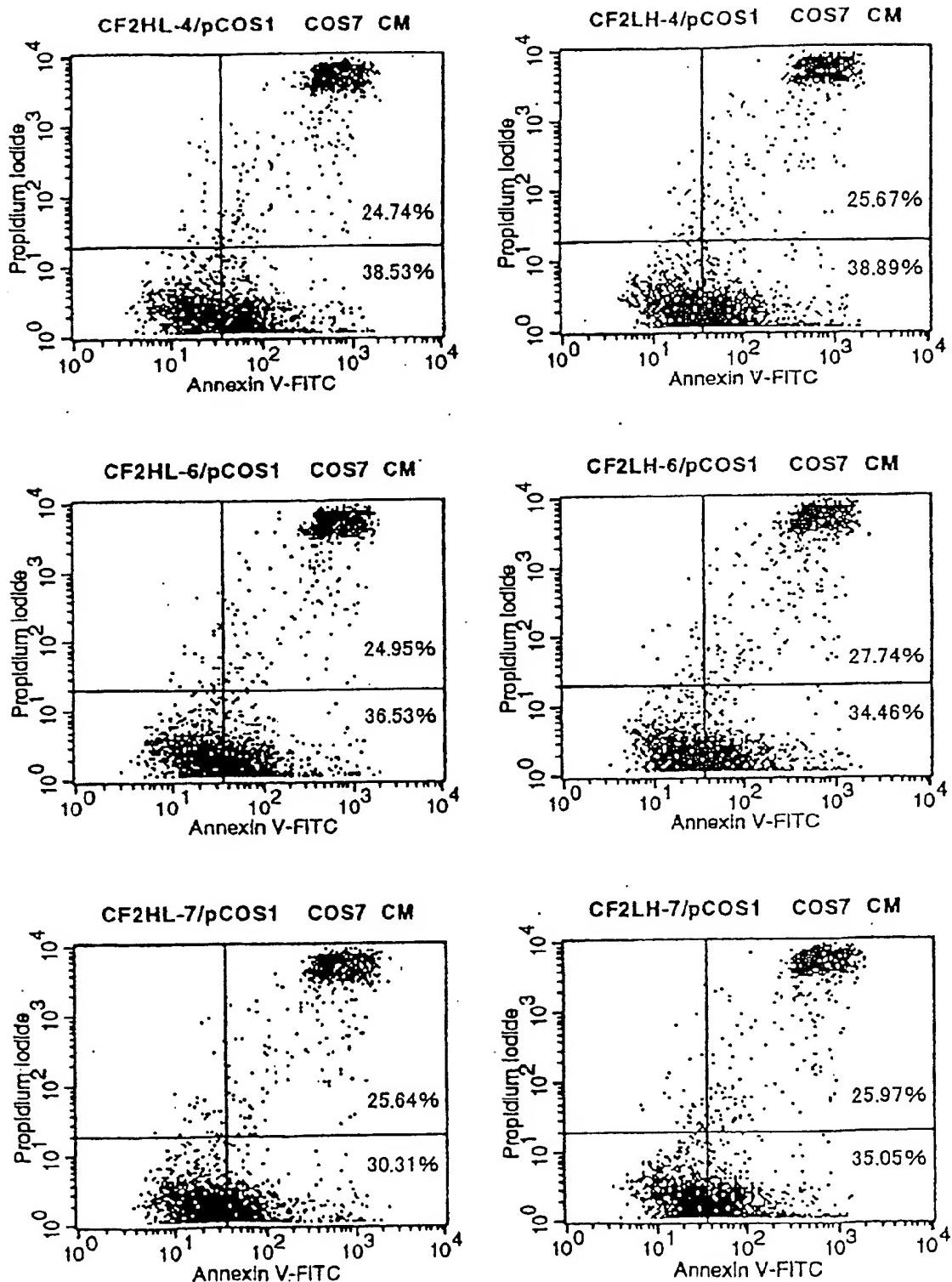


Fig. 42

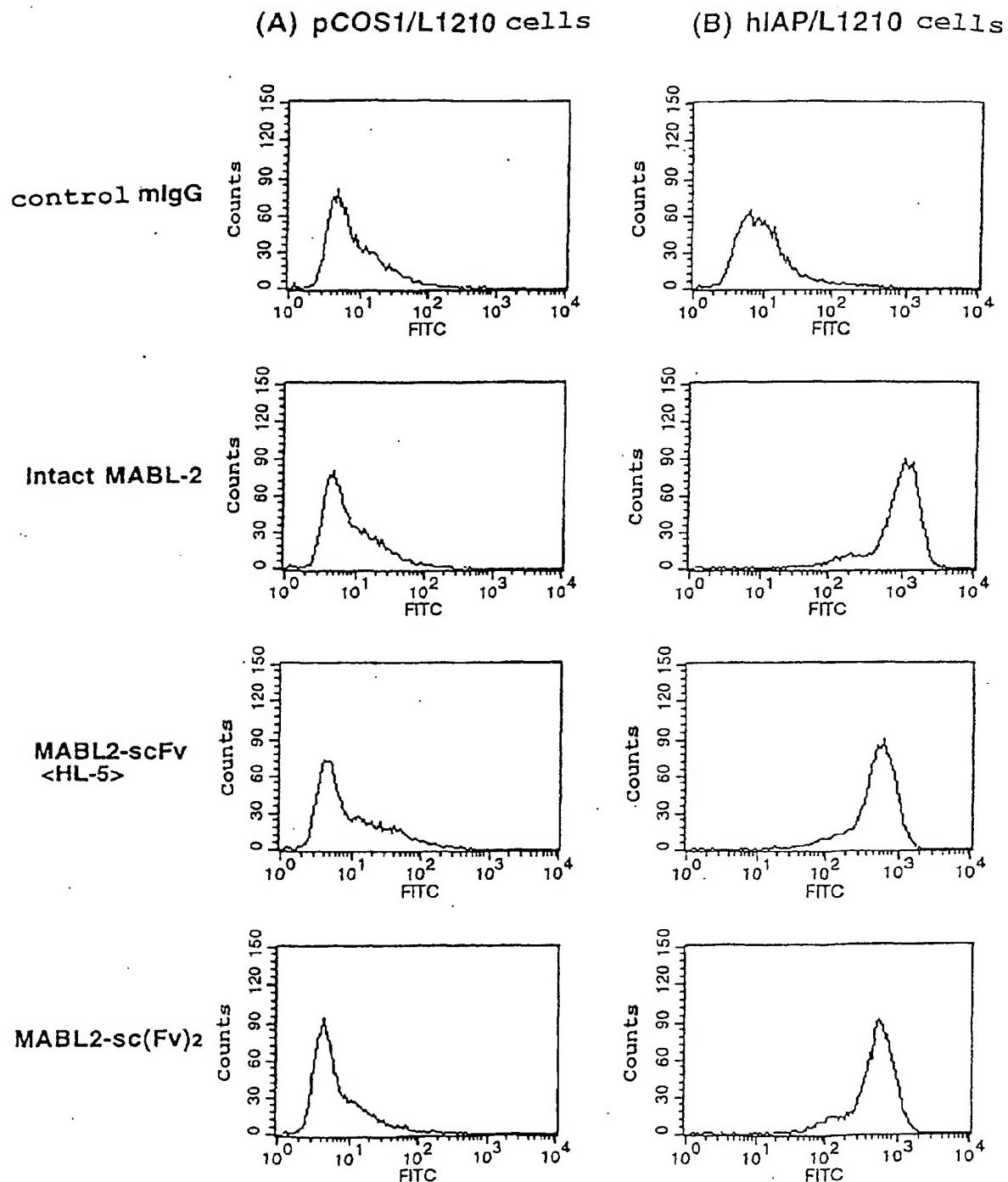


Fig. 43

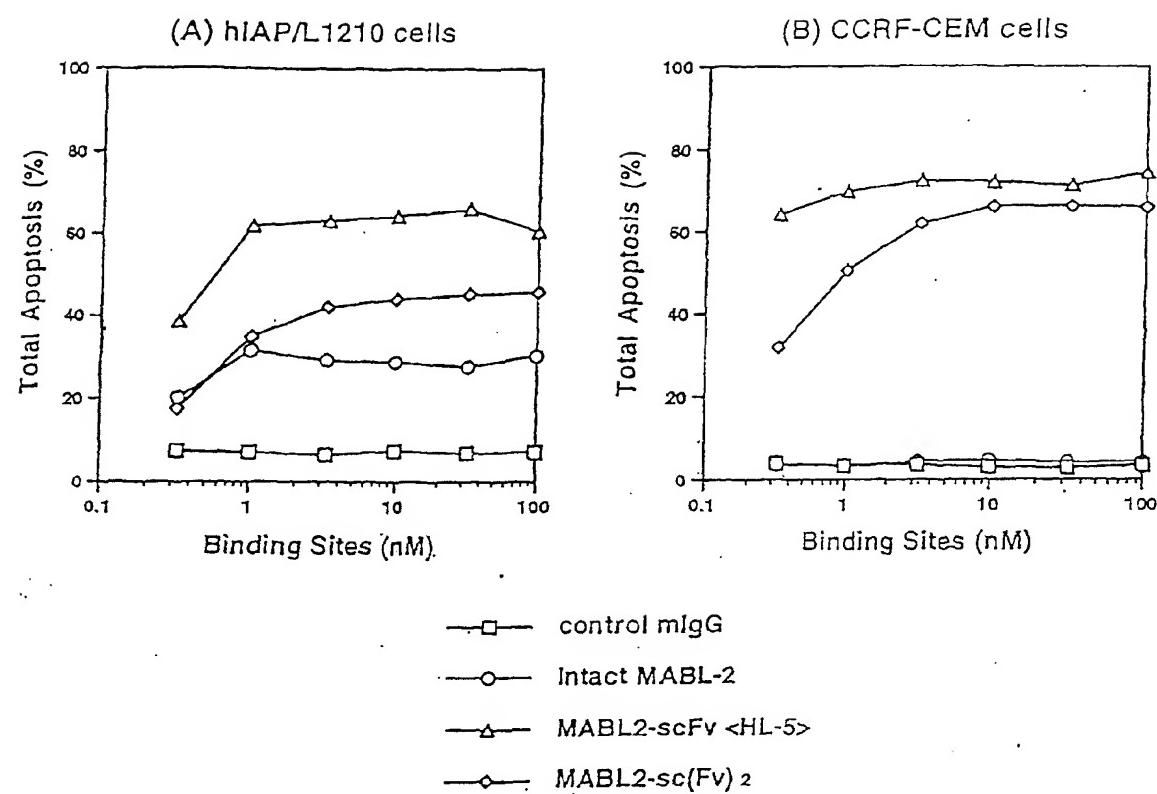


Fig. 44

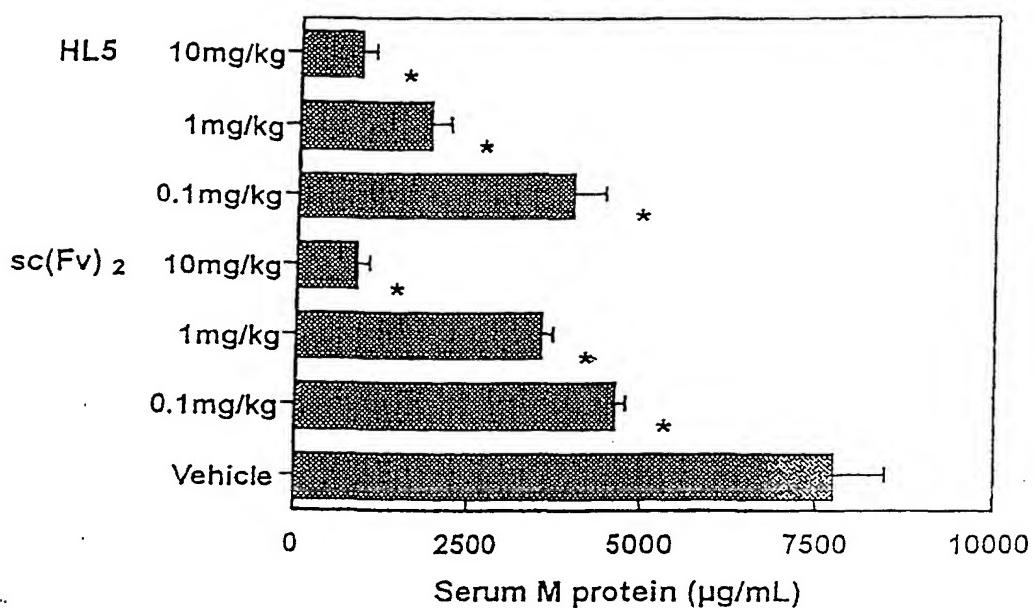


Fig. 45

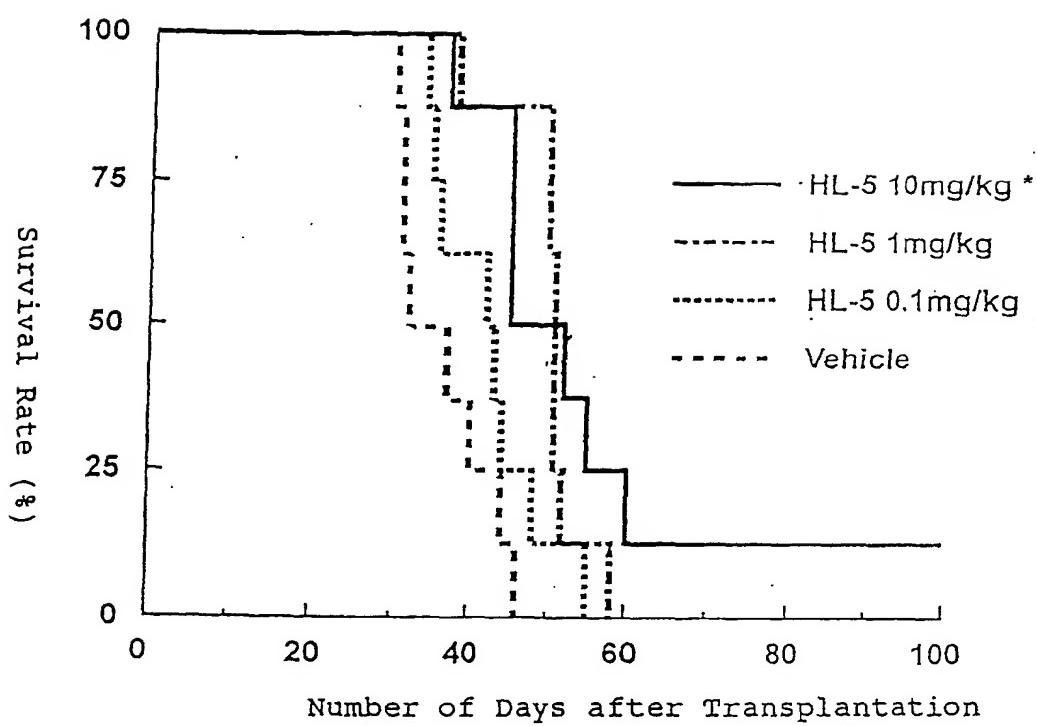


Fig. 46

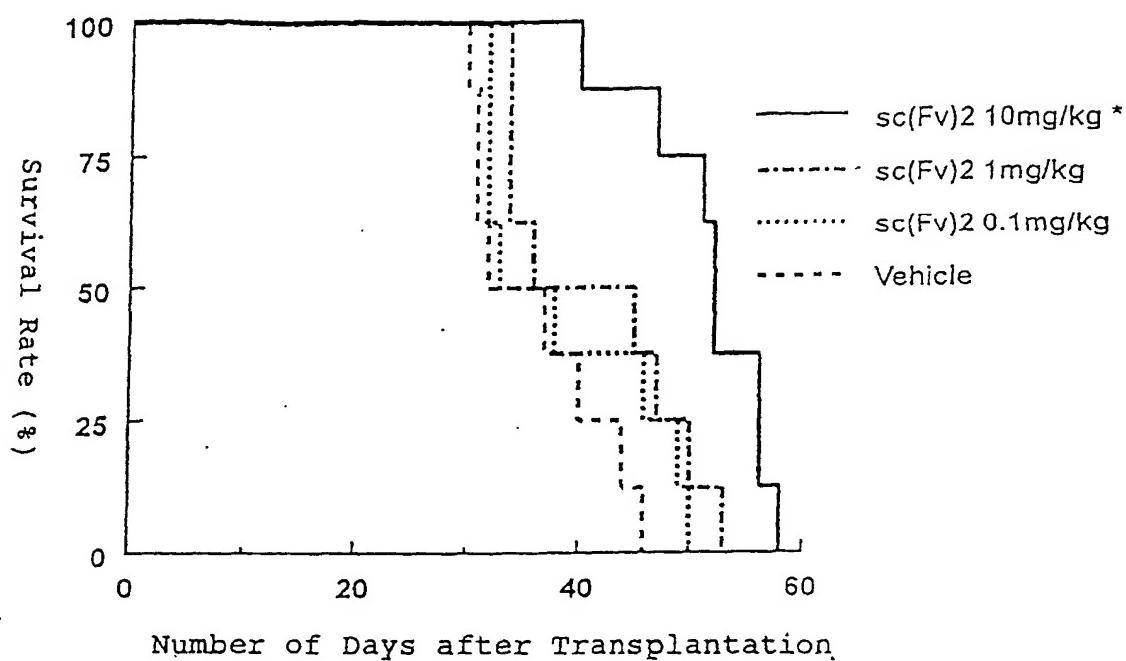


Fig. 47

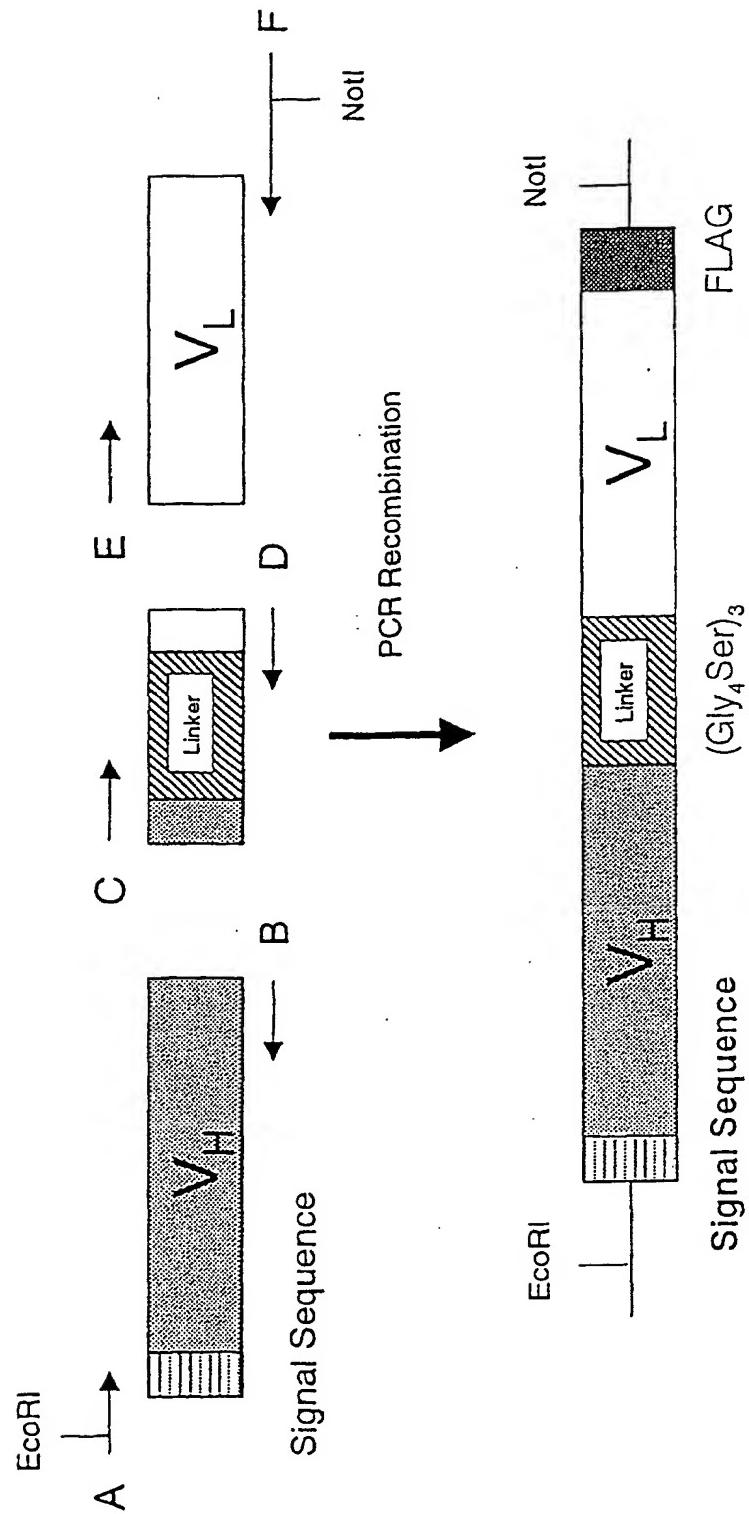


Fig. 48

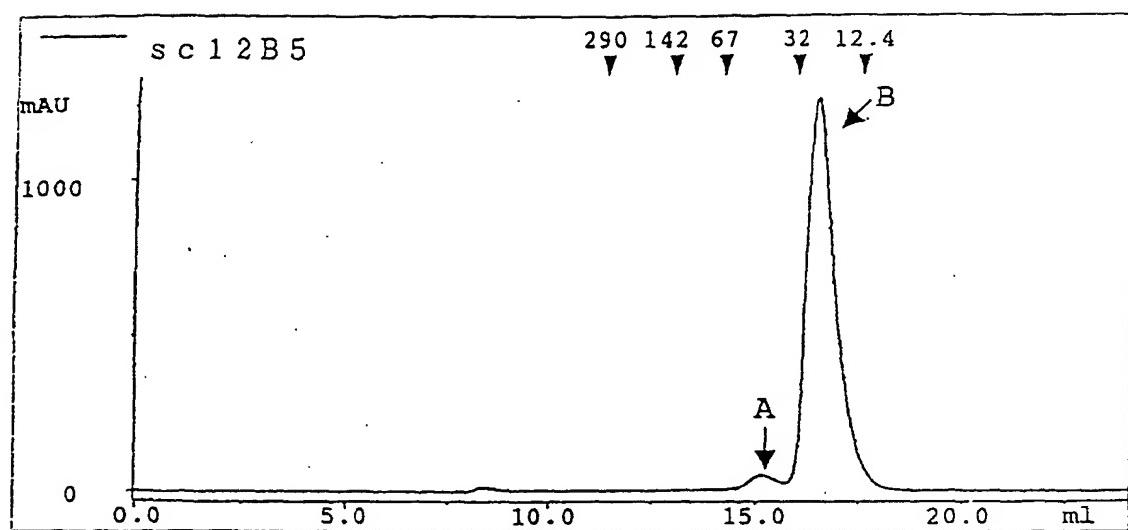


Fig. 49

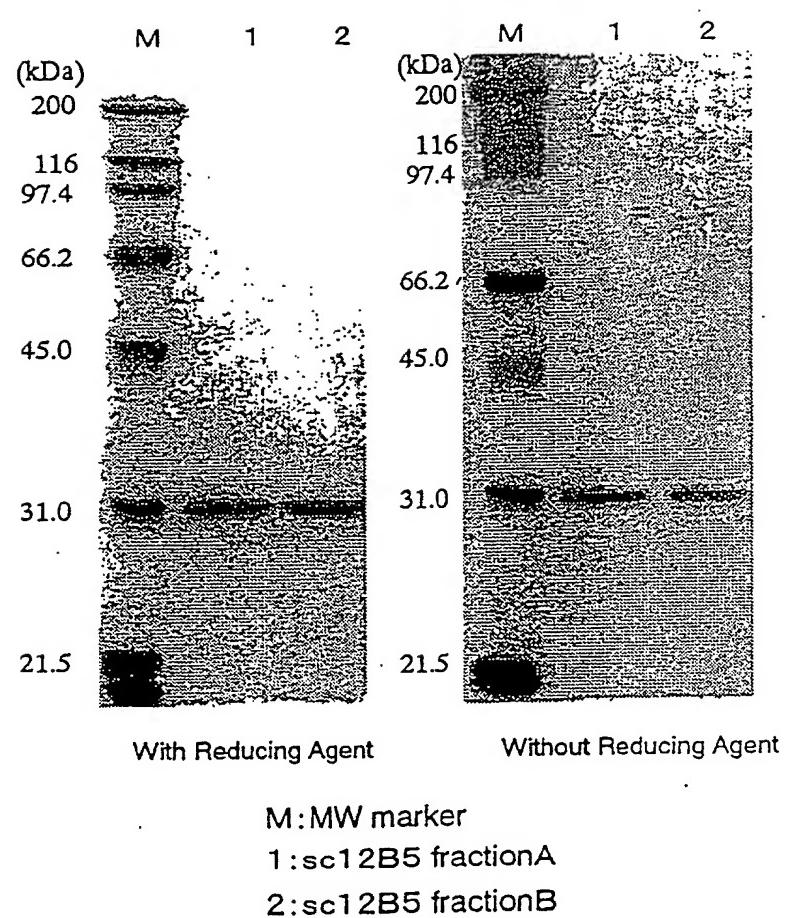


Fig. 50

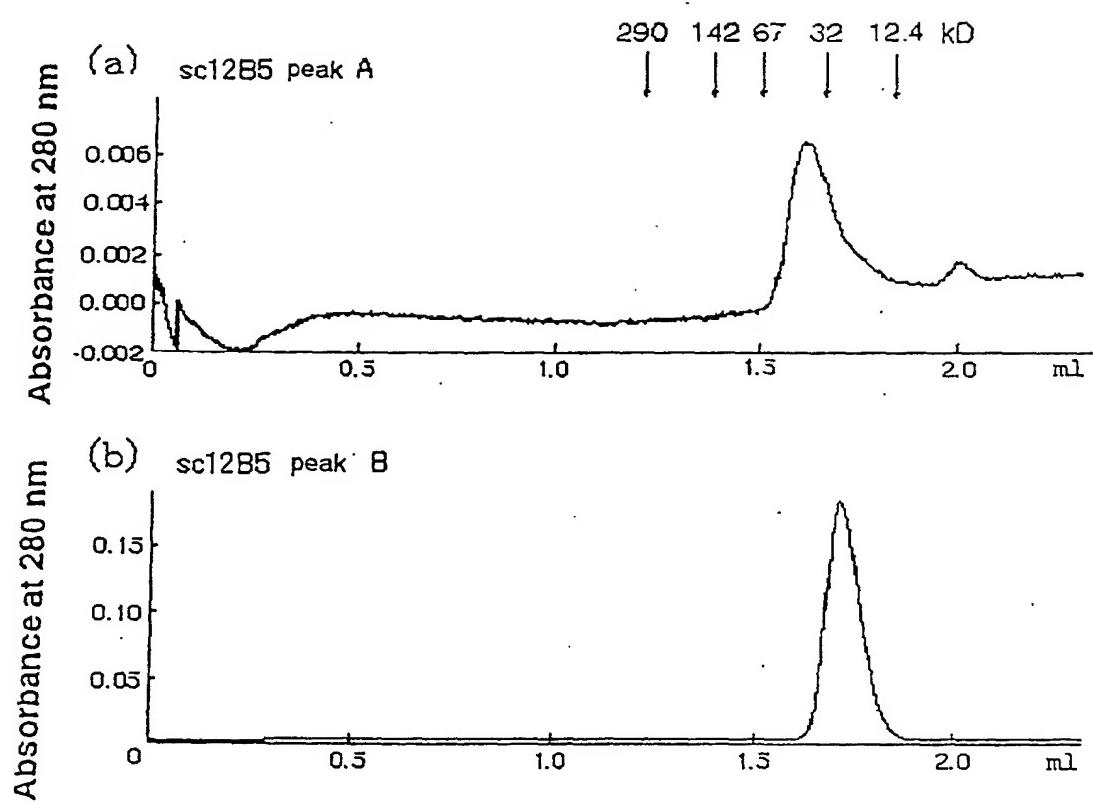


Fig. 51

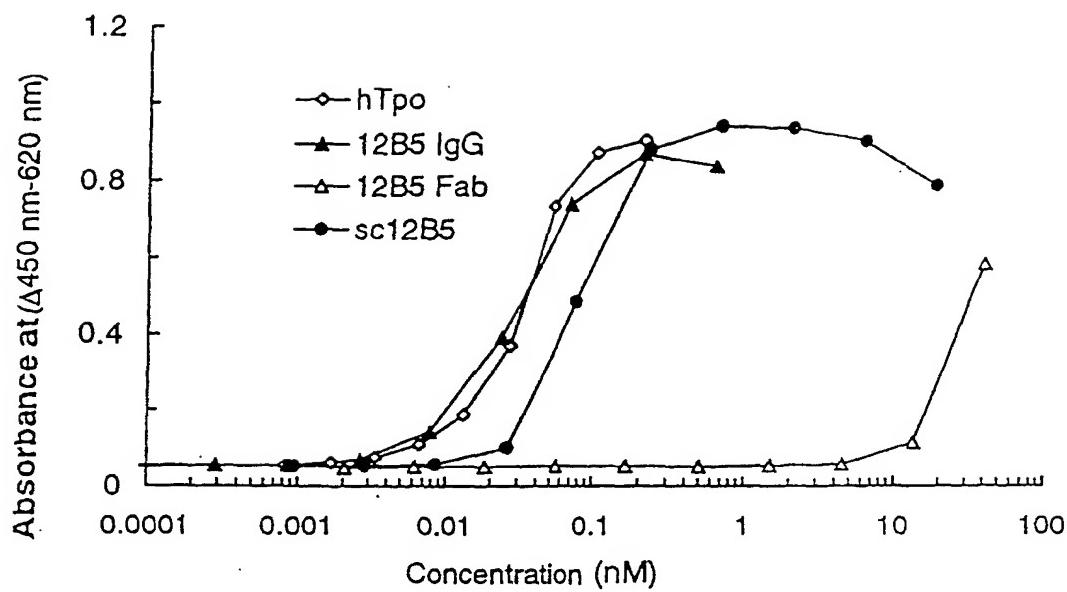


Fig. 52

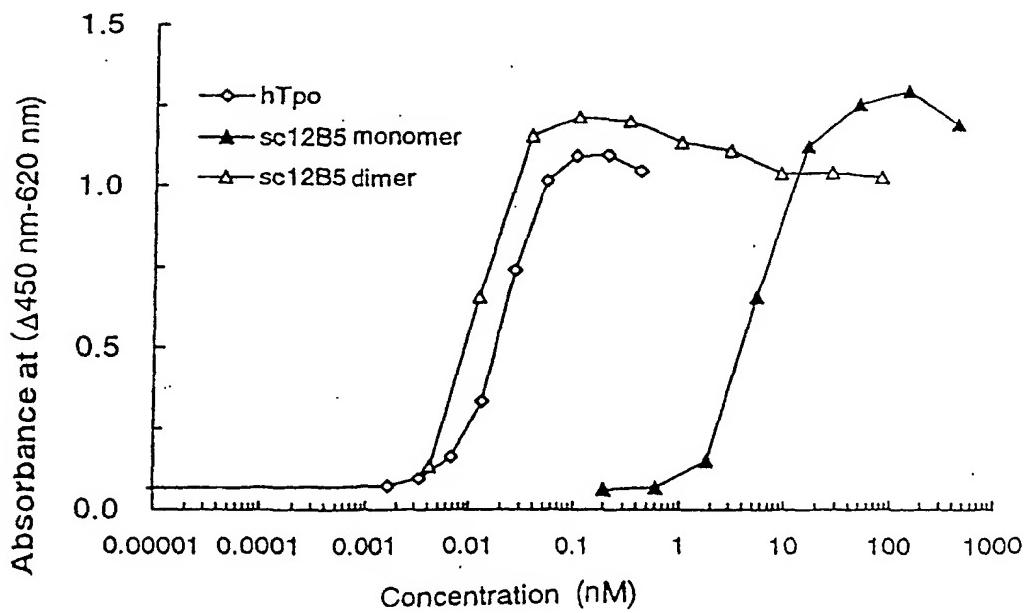
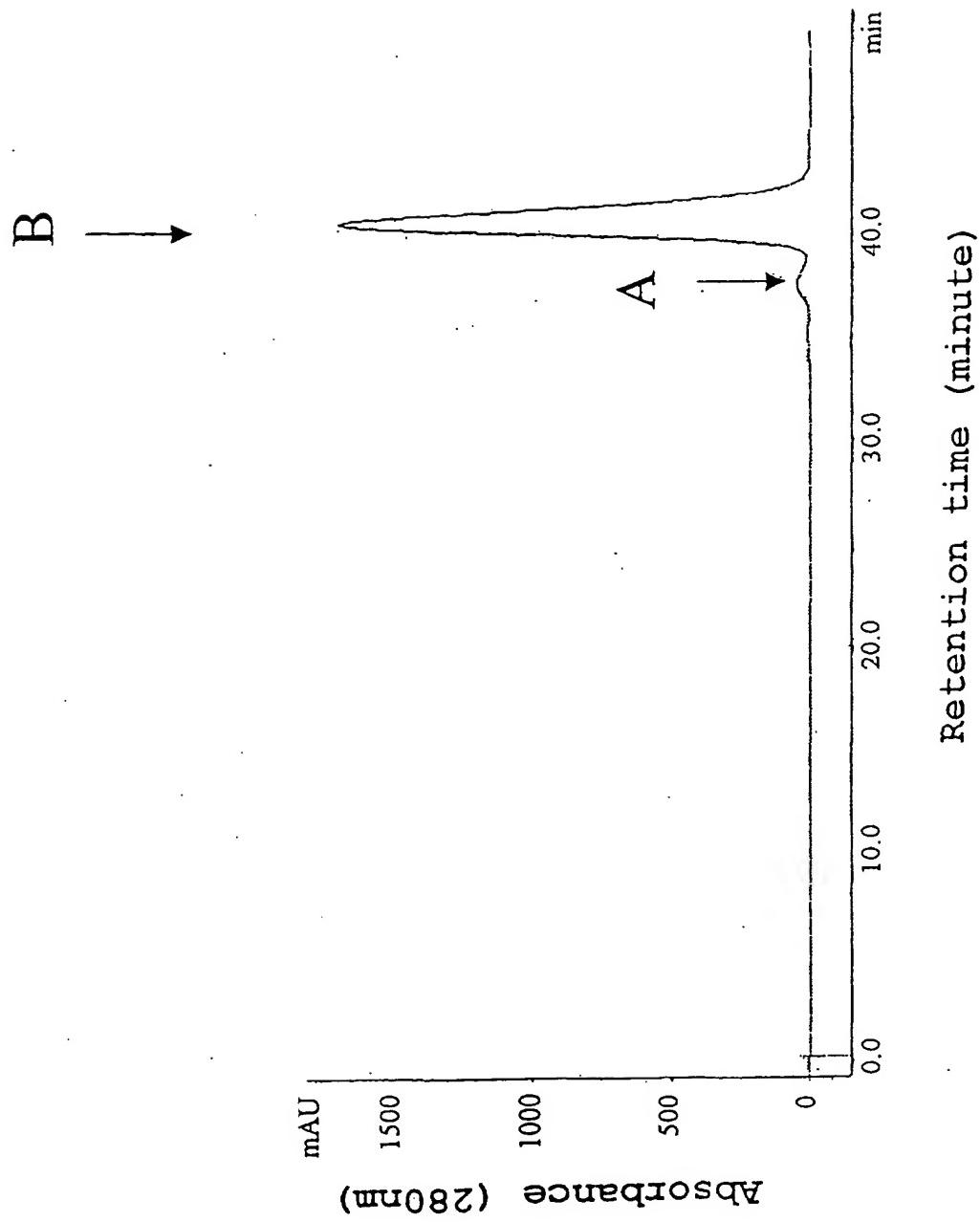


Fig. 53



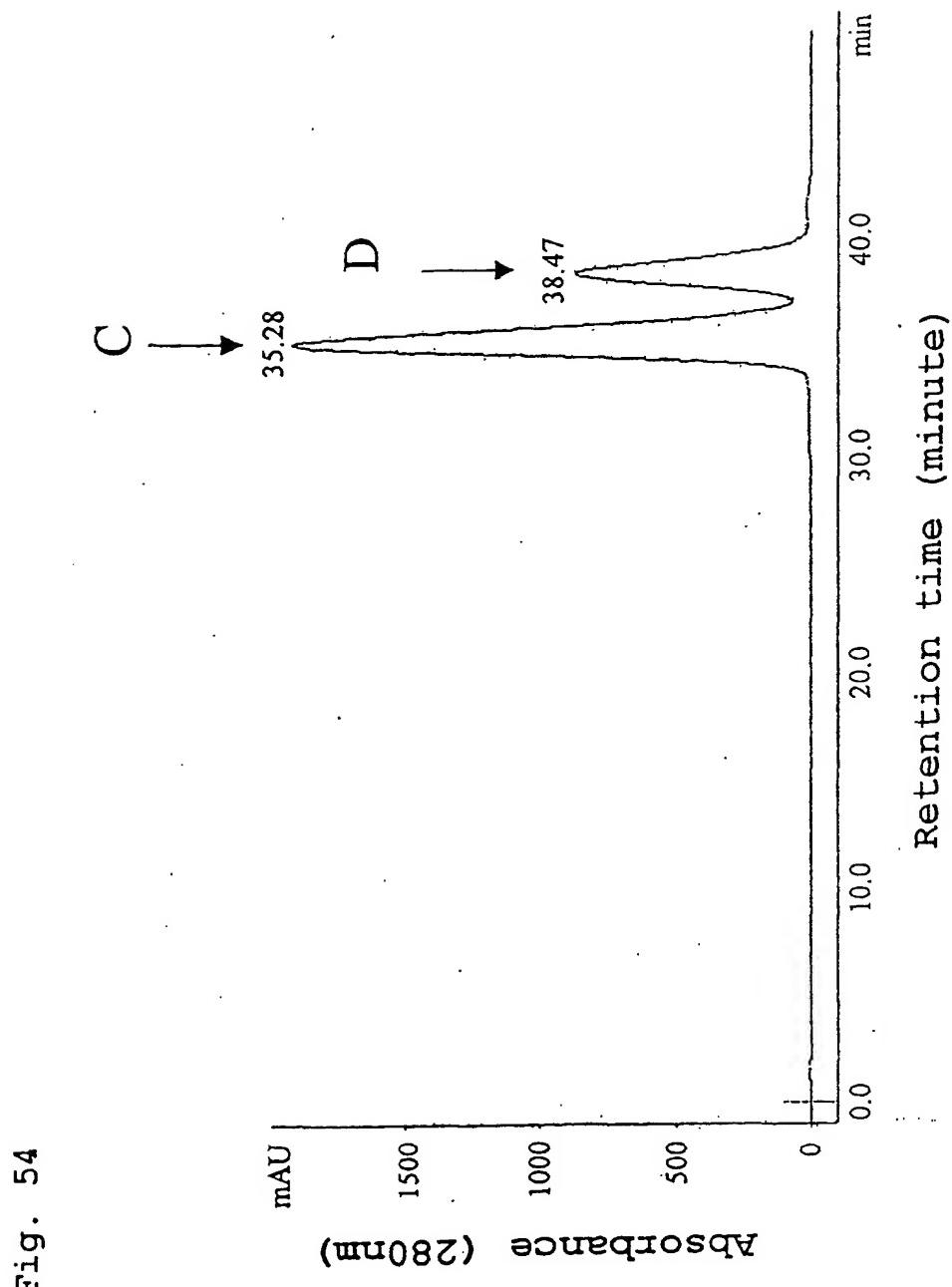


Fig. 5 5

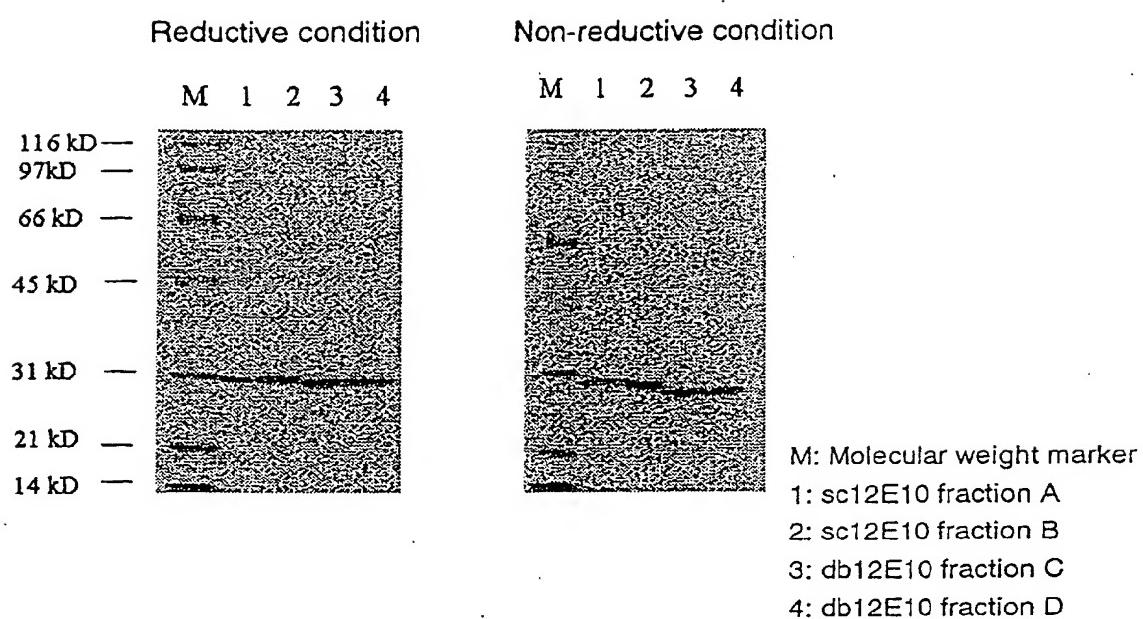


Fig. 56

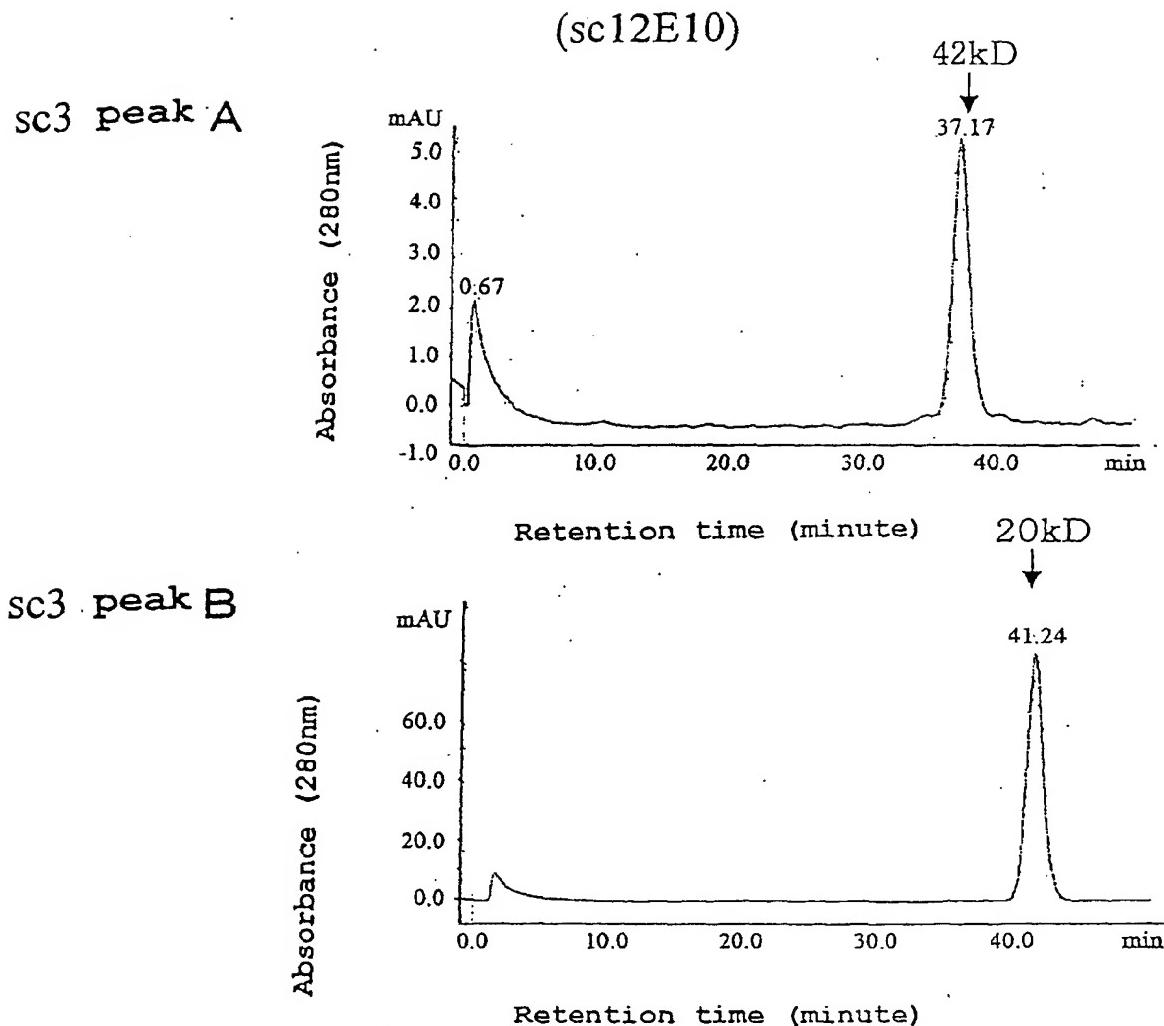


Fig. 57

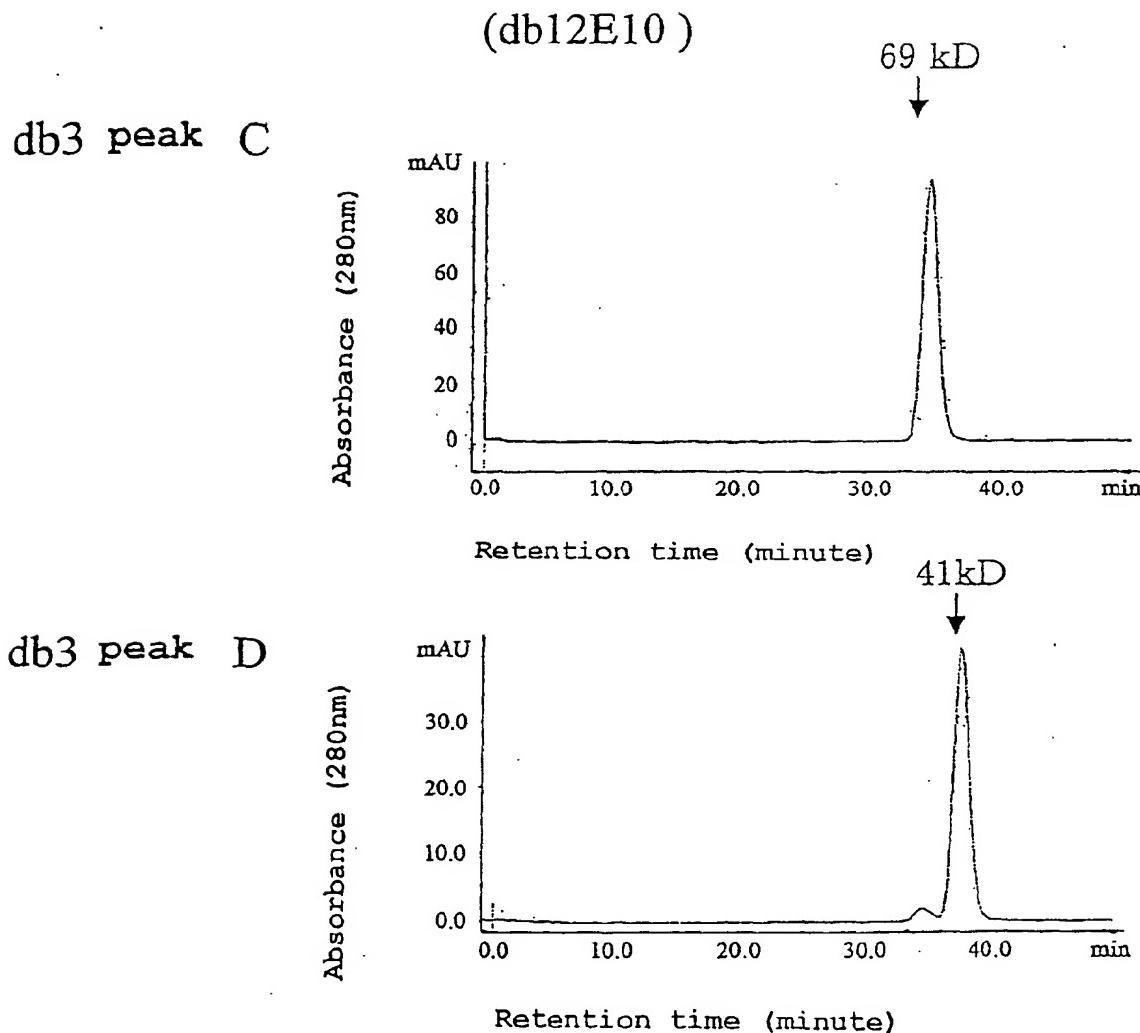


Fig. 5 8

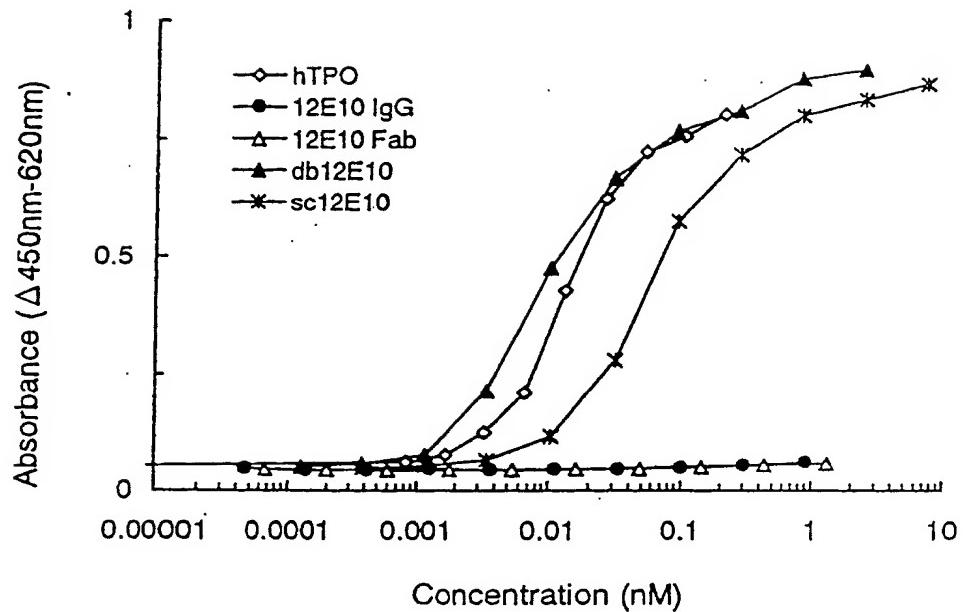
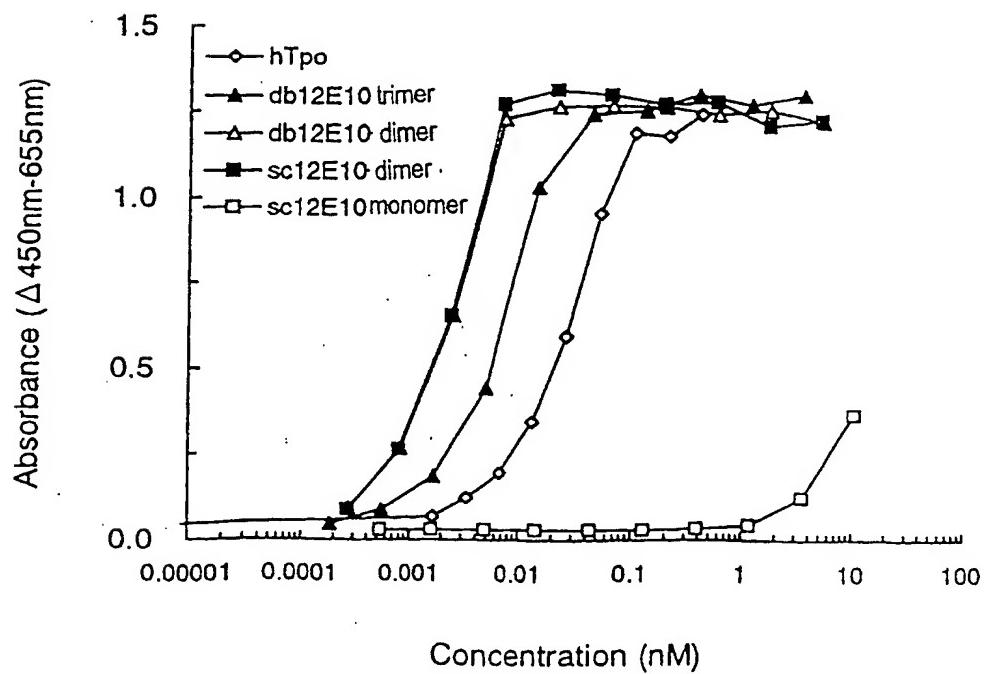


Fig. 5 9



INTERNATIONAL SEARCH REPORT		International application No. PCT/JP01/09259
A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁷ C12N15/09, 15/62, C07K16/28, A61K39/395		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int.Cl ⁷ C12N15/09, 15/62, C07K16/28, A61K39/395		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) JICST FILE (JOIS), MEDLINE (STN), WPI (DIALOG), BIOSIS (DIALOG)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Bijia DENG et al., "An Agonist Murine Monoclonal Antibody to the Human c-Mpl Receptor Stimulates Megakaryocytopoiesis", Blood, 15 September, 1998, Vol. 92, No. 6, pages 1981 to 1988	1-40
Y	US 5885574 A (Amgen Inc.), 23 March, 1999 (23.03.99), & JP 2000-95800 A & EP 773962 B1 & WO 96/03438 A	1-40
Y	KIPRIYANOV et al., "Bispecific CD3xCD19 Diabody for T Cell-Mediated Lysis of Malignant Human B Cells", Int. J. Cancer, (1998), Vol. 77, No. 5, pages 763 to 772	1-40
Y	WO 00/53634 A (Chugai Pharmaceutical Co., Ltd.), 14 September, 2000 (14.09.00), & EP 1167388 A	1-40
A	Ming-Hong XIE et al., "Direct demonstration of MuSK involvement in acetylcholine receptor clustering through identification of agonist ScFv", Nature Biotechnology, August, 1997, Vol. 15, No. 8, pages 768 to 771	1-40
<input checked="" type="checkbox"/>	Further documents are listed in the continuation of Box C.	<input type="checkbox"/> See patent family annex.
<p>* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family</p>		
Date of the actual completion of the international search 29 January, 2002 (29.01.02)	Date of mailing of the international search report 05 February, 2002 (05.02.02)	
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer <input checked="" type="checkbox"/>	
Faxsimile No.	Telephone No.	

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/09259

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1035132 A (Chugai Pharmaceutical Co., Ltd.), 13 September, 2000 (13.09.00), & WO 99/12973 A	1-40

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